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LEONOWA'S RECENT OBSERVATIONS ON THE ANENCEPHALIC AND AMYELIC NERVOUS SYSTEM.

C. Judson Herrick.

A few years ago Professor v. Leonowa of the Anatomical Institute at Moscow contributed a full description of the central nervous system of an anencephalic human infant.[1] The spinal cord was present and a very small part of the medulla, the latter terminating at the superior or sensory level of the decussation of the pyramids. In spite of the absence of the respiratory centre, the child lived 17 hours, 20 minutes. Microscopic examination of the cord showed a diminution of the number of the ganglion cells in the gray matter, a greater or less micromyelous condition of the white tracts and the total absence of two bundles; viz., the antero-lateral pyramids and the direct cerebellar tracts. The latter point of course is correlated with the absence of the cerebrum and the cerebellum and implies the downward, or centrifugal growth of these tracts.

More recently the same author has described[2] another case, a foetus of eight months about 34 cm. long, which was both anencephalic and amyelic and which presents so many points of general interest that we give here a full abstract of the paper.

Microscopic examination showed total rachischisis along the whole length of the vertebral axis, skull represented only by the base, without the cranial vault, the base containing a reddish, shapeless mass which v. Recklinghausen has called "substantia medullo-vasculosa," the lateral and superior parts of

[1] Leonowa, O. v. Ein Fall von Anencephalie. *Archiv f. Anat. u. Phys.*, 1890, Anat. Abth., pp. 403–422. 1 plate.

[2] Leonova, O. v. Contribution à l'étude de l'évolution pathologique du système nerveux. Anencephalie totale combinée avec une amyelie et un rhachischisis totaux chez un embryon humain. *Bulletin de la Société Impériale des Naturalistes de Moscou*, 1893, No. 2-3.

which were bordered by skin. Some well developed curly hair covered the skin surrounding the substantia medullo-vasculosa. In the gaping vertebral canal was a quantity of longer or shorter tangled threads, of various degrees of fineness, filling the canal. They sprang from oval formations situated in the intercostal spaces. These oval formations were nothing other than the spinal ganglia and the threads referred to—the dorsal roots of the spinal cord into the dorsal part of which they seemed to be directed. These spinal ganglia also possess peripheral roots representing the peripheral nervous system. There were nine ganglia on the right side and ten on the left. After the most minute examination there were discovered on the left side under the occipital bone three little ganglia connected with each other. One root went from the inferior ganglion without passing through the foramen ischiadicum majus and terminated on the surface of the glutæus majus. Some roots arising from certain of the ganglia passed through this foramen and, passing towards the muscles of the lower extremities, united with the root of the inferior ganglion to form a sciatic nerve. Other ganglia gave rise to roots which were directed towards the intercostal spaces. The last superior ganglia formed the plexus brachialis. Ventral roots absent, hence also motor fibres. In spite of this the striated muscles of the body were normally developed, a fact of great scientific interest, especially to the physiologist.

As to the sense-organs, ear and eye normally developed; the optic nerve terminating simply in the substantia medullo-vasculosa. In the microscopic examination a normal human embryo of eight months about as long as the monster served as a control. The transverse and horizontal dimensions of the spinal ganglia were less in the pathological case than in the normal, but this is wholly due to the absence of the motor fibres. In the monster the quantity of fibres was less, as shown by the less intense coloring with hæmatoxylin, and the whole section was covered with a granular mass. On the lateral side of the sections some empty oval formations look like the neurilemma of the absent motor bundles. The brachial plexus shows the same relations as the sciatic nerve. Cutaneous nerves medullated in their superior courses and everywhere near the skin; nervous termini within the muscles, a bundle enters into the deeper layer of the M. tibialis and ends in a plaque, resembling the termini of the peripheral motor fibres in the striated muscles. To admit that this bundle is motor, would be contrary to our actual knowledge, and the facts mentioned are moreover not sufficient to support this supposition. Posterior roots probably without myelin; optic nerve destitute of nervous elements; retina with neither ganglion cells nor nerve fibres; texture of the sympathetic ganglia normal.

A review of these facts leads us to the following important conclusions:

(*1*) *The development of the peripheral sensory nervous system does not depend upon the central nervous system, since the former can occur and develop progressively in the total absence of the ence phalon and even of the spinal cord.*

(*2*) *The peripheral sensory nerve fibres originate from cells of the spinal ganglia and are the prolongations of their axis cylinders; for this reason we ought to look upon the cells of the spinal ganglion as a primary nucleus* (*Zellencomplex*), *as a veritable nucleus of sensory fibres.*

The cells of the spinal ganglia have for the sensory fibres the same importance as the motor nuclei of the brain base and the cells of the ventral cornua of the cord have for the motor nerves. The works of Kölliker, His, Ramon y Cajal and Lenhossék, as well as the author's own researches, enable us to affirm that the sensory fibres do not have central nuclei, a fact of great general importance which may be observed not only in the peripheral sensory fibres and in the dorsal spinal roots, but also in the sensory roots of the cranial nerves, as His has shown in his "Gangliennerven des Kopfes." So likewise we are obliged to regard the cells of the retina from which the optic nerve arises as the ganglion of the optic nerve. Pathological researches, the method of v. Gudden, the results of Ganser who brought about the atrophy of the ganglion cells of the retina by extirpation of the tractus opticus, the histological researches of v. Müller and the illustrious works of v. Monakow show that the cells of the corpus geniculatum externum are not a nucleus of the optic nerve, not a "Zellencomplex" in the sense of His.

The presence of the striated musculature when there is total absence of motor roots is unquestionably a fact of great importance and shows us that the cells of the ventral cornu of the spinal-cord do not play any role as trophic centres for muscles. In other words, the development of the striated muscles, which are formed from mesoderm, does not depend, up to a certain given moment, upon the cells of the ventral cornu and the development of the muscular system is possible even in the absence of the spinal cord, motor cells and roots; the presence of the sensory ganglia and nerve-fibres suffices for this development. At first sight the pathologico-physiological data of the adult organism seem to contradict this, in view of the fact that alteration of the cells of the ventral cornu of the adult cord invariably produces a pronounced muscular atrophy. This contradiction is easily explained by the difference between the functional role of the ventral cell of the adult spinal cord and that of the embryonic cell. Moreover, in the adult cord, aside from the purely anatomical connection there is a functional connection. The functions of the muscular fibres—protoplasmic contraction, voluntary movement—are the result of impulses carried from the cell toward the muscle. The vital function of the muscles, that is to say, movement, depends upon the ventral cells of the cord, which are also responsible for the nutrition of the muscles of the adult organism. These facts elucidate the general law of trophic nerves: *a functional connection between two organs implies also the idea of a trophic connection.*

The author's conclusion, as here expressed, is of great importance and if properly understood and applied would render unnecessary much of the recent theorizing upon the subject of trophic nerves and trophism in general. It cannot be too strongly urged that every physiological connection in the body is a *mutual* relation. No organ can exert an influence upon another organ without being itself modified thereby to a greater or less extent. The body is a vital unit and any attempt to revive the Cartesian notion of a dominant central directive force which governs despotically the activities of growth and normal physiological function is a step backward. Whenever a physiological union is to be instituted between one part of a growing embryo and another part, the impulse from one side is met by a reaction from the other. This is well illustrated in the development of the sensory ganglia by the fact that cotemporaneous with the centrifugal ganglionic outgrowth there is a thickening of the epidermis of the corresponding region and it requires both of these elements to form the completed ganglion. Hereditary cell-forces are in operation on both sides; and furthermore unless these forces are both kept operative throughout life there will inevitably be degeneration, as is shown by the atrophy of the primitive embryonic sensory ganglia of the first segments of the head region, the degenerations following amputations, etc.

To return to Professor v. Leonowa's paper, he calls attention to the fact that this case is a confirmation from a third point of view of Waller's law. This law in its most general form states that after section of a nerve degeneration follows the customary path of the stimulus and proceeds in the direction of the stimulus. This was based upon experimental researches. His and many others after him have shown by purely embryological methods that the embryonic growth is in the same direction; and now we have even stronger evidence from the side of pathology.

Waller's law, however, is completed by the following facts; (1) Section of sensory and motor roots between the ganglion and the cord is followed by the atrophy of both of the roots remaining connected with the cord; (2) Section of the root between the ganglion and the periphery causes the destruction of the peripheral part and of the ganglion also. These observations apparently contradictory to Waller's law do not essentially alter it, for according to recent researches the destruction of the ganglia, the atrophy of the motor fibres, the destruction of the motor cell of the ventral cornu of the cord, all result from one and the same law: *the abolition of the function of the cell*; in other words, when one member of the functional group is destroyed the other suffers also and the result is the same whichever member is first affected.

This case, too, we may add, has an important bearing upon the problem of the ultimate source of the cranial and spinal ganglia with the peripheral nerves related to them. His in 1890 affirmed that these ganglia arise neither from the epidermis nor from the nerve-tube, but from a band of ectodermal elements lying between the two (*Zwischen Strang*). Baird, on the other hand states that the *Zwischen Strang* is not nervous at all and that the real proton of the ganglia is derived primarily from the nerve-tube, with a subsequent reenforcement from the skin, so also Balfour, Van Wihje, Froriep, Kupffer. Still more recently Mitrophanow[1] has adduced evidence to show that in Selachians the peripheral nervous system with its ganglia is derived from the central system, and that the nerve-tube is completely closed and separate from the ectoderm before this process begins. Since the entire central and peripheral nervous system arises from a single proton, he would insist that any segmental arrangement exhibited by the latter, as in the sense-organs and the organs of the lateral line, must be due to preexisting arrangements of the body to which the nervous outgrowths conformed by secondary adaptation. It is hard to reconcile these observations with the presence of well developed spinal ganglia and nerves exhibiting the normal metameric arrangement, in the total absence of both brain and spinal cord. It is highly important that Professor v. Leonowa's suggestive observations be extended and, if possible, that the early embryonic conditions in such cases be studied in order to determine whether the brain and spinal cord were absent from the first or whether it is a case of atrophy of organs primitively present.

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[1]See p. xxxiii of this number.

STUDIES FROM THE NEUROLOGICAL LABORATORY OF DENISON UNIVERSITY.

VIII. Glands and Nerve-Endings in the Skin of the Tadpole, with Plate I.

By J. H. Massie, A.B.,
Fellow in Physiological Psychology.

The skin of the full-grown tadpole is made up of two layers, the cuticle, or epidermis, and the cutis vera, or corium. Its development may be divided into three stages, arranged as follows:

First, the early embryonic period, before the layers of the skin have become well differentiated from the primitive mass of ectoderm.

The second stage is marked by the subdivision of the epidermis into a columnar Malphigian layer and an outer horny layer of thick-walled, much flattened cells and the appearance of a narrow band of corium.

The third stage begins when the tadpole is about 3 cm. long and extends to the metamorphosis. The cells of the Malphigian layer at the initiation of this stage begin to enlarge, elongate and differentiate into two groups. In each group the cells are triangular and in all cases the nucleus of the cell is at the base of the triangle. In the one case the bases of the cells lie adjacent to the corium, in the other, to the horny layer. (Plate I, Fig. 4.) Each group, then, presents a serrated front to the other; and, as the cells alternate with perfect regularity, the salient angles of the one fit into the reentrant angles of the other. During the process of hardening the various layers of the skin often shrink away from each other, and not infrequently the two elements in the Malphigian layer are separated, one adhering to the horny layer, the other to the corium. For convenience we shall call the cells of the Malphigian layer whose nuclei are adjacent to the horny layer the ectal division, the others the ental division. It will be seen that the nuclei of these ectal and ental cells differ in arrangement and in structure, thus perhaps portending a difference in function. The ental nuclei are of loose, reticular texture and lie with their long axes parallel to that of the cell. The ectal nuclei are denser and lie transversely in their cells. At this stage, then, the epidermis is made up of three kinds of cells; namely, the horny layer, containing much flattened cells, and the Malphigian layer which consists of ectal and ental cells serrately arranged.

The cutis vera, or corium, consists in the second stage of a single band of closely compacted connective tissue fibres and has a wavy appearance. Just before the metamorphosis there is developed a superficial layer. This is a loosely meshed and much pigmented layer and ultimately forms a support for the glands. At this same time may be seen the deepest layer of corium. It lies just beneath the dense wavy layer and contains a delicate mesh-work of connective fibres, nerves and blood-vessels. By means of this layer the corium is connected with the underlying organs.

No glands or indications of glands are seen until just before the metamorphosis. At this time the nuclei of the ental cells of the Malphigian layer become more granulated and at certain places they divide rapidly, forming nests of small dense cells, from which the glands are formed. These bunches of cells push aside the loosely connected superficial layer of the corium and the fibres of connective tissue now are crowded together so that they have the appearance of closely compacted bundles running at right angles to the corium. Through these the nerves now reach the epidermis. (Figs. 2 and 6.)

At a stage somewhat earlier than that just alluded to there may be seen in the ectal cells of the Malphigian layer peculiar skein-like bodies (Figs. 3, 4). They bear some resemblance to nerves and indeed have been mistaken for them. Pfitzner[1] in frog larvæ of about the same age as those here described (i. e.,

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[1]Nervendigungen im Epithel. *Morph. Jahrbüch.*, Bd. VII, 4 Heft, 1882.

at the stage just preceding the appearance of the front legs) has described them as nerve termini. He has postulated a theory which runs somewhat as follows: Each cell of the epithelium is supplied with two nerve fibres, one sensory, the other motor, which end free in little knobs within the cell. When the cells divide these nerve fibres divide also, so that each new cell is supplied with a branch from both the primitive motor and the primitive sensory nerve.

But under favorable circumstances with thin and carefully prepared sections by close examination these peculiar nerve-like structures can be distinguished from nerves. For, although they react with some stains like nerves, with others they give a different color; moreover they are too large for nerves and, so far as we could see after examining a great many sections differently stained, they lie wholly within the cell-walls. They are never seen in the ental cells of the Malphigian layer but are confined to the members of the ectal series. We would therefore say that they are not nerves, but fibres of linin or chromatin, which serve a special purpose in preparation for rapid subdivision at the time of the metamorphosis. This view receives confirmation from the fact mentioned by Pfitzner that these filaments are more conspicuous at this stage than at any other, and also from the fact that at this stage there is a rapid subdivision of cells of the ectal layer to form a second row of cells in the horny layer. The latter unquestionably springs from the cells of the ectal layer only. At this time the intra-cellular skeins often break up and assume forms strongly suggesting mitotic figures. (Fig. 2.) We believe therefore that the ectal cells of the Malphigian layer have a different function from the ental cells. The latter form the glands and at an older stage rapidly shrink in size. The former supply the horny layer with new cells and the peculiar thread-like bodies within them have an active part to play in cell-division.

After examining much material prepared in different ways, we believe that the nerve bundles from the central nervous system send out toward the skin medullated nerves which on reaching the closely compacted middle layer of the corium run parallel to it until the points of least resistance are found, that they then penetrate and send non-medullated nerve-fibres among the epidermal cells, where they branch freely but in no case penetrate within the cell walls (Figs. 1, 2, 5.)

Kölliker in his "Histologische Studien an Batrachier Larven"[1] thinks that at first the nerves are non-medullated and are in the form of pale anastomosing branched fibres. Even at this early stage they are composed of a central fibre, or axis-cylinder, and a sheath. In the earliest stages he agrees with Hensen in saying that these fibres are without nuclei. As the nuclei are absent when the nerves emerge from the cord, they must either arise *in loco* or apply themselves to the fibres from some other source. He notices that the intervals between nuclei are greater in earlier than in later stages, that the nuclei multiply by mitosis, and he is inclined to the view that they are applied to the exterior of the sheath from without. As to the nature of the peculiar skein-like bodies in the cells he is undecided; he notices, however, that they rarely, if ever, reach cell-walls. He thinks that they are not nerves and says that their function and chemical composition are unknown. Mitrophanow also finally decides against the nervous nature of these thread-like bodies and says that the nerves end free among the epidermal cells.

Most of the sections which we have examined were prepared by the paraffine method after hardening in dilute chrom-acetic for 24 hours. Some were stained with aqueous hæmatoxylin, some with hæmatoxylin and picrocarmine, others with hæmatoxylin and acid fuchsin. The latter served especially well to differentiate the nerve fibres from the intra-cellular skeins.

DESCRIPTION OF PLATE I.

Sections through the skin of the tadpole of the frog at different ages, all taken shortly before the metamorphosis, between the appearance of the hind legs and that of the front legs.

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[1]Zeitschrift für wissenschaftliche Zoologie, XLIII, 1, 1886.

Fig. 1. Illustrating a nerve terminus in the skin at about the middle of this period. The principal fibre shown is medullated up to the dense middle layer of the corium, where it loses its sheath and then follows a sinuous course over the surface of the cells of the Malphigian layer. The ectal and ental cells of this layer are well differentiated.

Fig. 2. Section through the skin of an older specimen. The horny layer is now two cells thick throughout, the ectal series of Malphigian cells is rapidly subdividing and the intra-cellular skeins have in several cases assumed stellate forms. A gland is shown in process of formation at the right and at the left a nerve fibre passes up through the corium and branches over the surface of the epidermal cells.

Fig. 3. Section through the skin at a considerably younger stage. A blood-vessel is seen under the Malphigian layer. Most of the corium has been torn away.

Fig. 4. Section from a little older specimen than the last, showing a slightly different typical form of intra-cellular skein; *h*, horny layer, beginning to become two cells thick, *ec*, ectal series of Malphigian layer, *en*, ental series.

Fig. 5. Section of about the same stage as the last, showing the three layers of the corium. Below the lowest layer a nerve-bundle is seen, which sends a fibre up to the epidermis, where it branches freely over the cells of the Malphigian layer.

Fig. 6. Section showing a gland at a slightly more advanced stage than the one illustrated in Fig. 2.

IX. Comparative Study of the Epiphysis and Roof of the Diencephalon.

By A. D. Sorensen, A.B.
Fellow in Neurology.

The object of the present work has been to present, in addition to the original matter, a more complete historical account of the studies of the epiphysis and the roof of the diencephalon than has yet appeared. For this purpose the original articles have been largely reproduced.

To enhance the value of the appended bibliography it has been thought best to include the names of investigators whose papers have not been available, as well as those here presented.

Historical Account.

Brandt[1] (*8*) described the skull of Lacerta agilis as follows : Occipital plates, 4 ; seldom only 3 ; the two most median situated behind one another, the smallest, the upper, larger, regularly 5-cornered, most median, with a round sunken spot, and he adds in a foot note : marking a special glandular spot. The external marking on the surface of the head is not represented in his drawing of L. agilis, (fig. A. Taf. XIX), but his description shows that he recognised the presence of an internal modification corresponding to the specialized scale.

Milne Edwards[1] (*17*) and Duges[1] (*14*) both figure the external modifications in certain lizards, but neither, strangely, makes the slightest mention of it in his descriptions of the animals.

Reissner (*75*–'51) first represented the pineal projection correctly and

Reichert (*74*–'61) called it the recessus pinealis v. supra-

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[1]Fide Spencer.

pinealis. The former gave no explanation of the projection and the latter found no connection between the projection and the pineal gland development.

Meynert (*57*) considered the structure of the pineal gland nervous, and thought it was the ganglion from which the tegmentum arose.

Henle (*32*–'71) took the pineal for a lymph gland which functioned as such in the embryo, but later, as the stream of lymph entered other courses, a degeneration took place. Further, Henle found that the pineal in man consists of follicles (.06–.03. mm.) which are more or less separated from one another by connective-tissue; later the substance of the follicles is formed of cells having the appearance of lymph bodies, still, for the most part, somewhat larger (.015 mm.), of cubical form and with globular nuclei. The union with the nervous system is only external; no fibres leave the commissure of the stalk to enter the gland and the few nerve fibres present belong only to the blood vessels.

Bizzozero (*6*), contemporaneously with Henle, studied the structure of the pineal gland. He describes a reticulum in whose meshwork lie large and small cells provided with projections; in the new born the projections are wanting. In addition to the foregoing casual references, Mihalcovics gives an historical resumé at the end of his paper, in which he divides the investigators into three groups. First, those representing in part the oldest views, who considered only the exterior, as the size, form and consistency; second, those who recognised that the gland arises from an evagination of the roof of the diencephalon, but did not understand the method; and third, those who explained the entire process quite fully.

Group I. Here belong J. and C. Wenzel (brothers), Tiedmann, Serres, Rathke, and Reichert.

J. and C. Wenzel (*93*–'12. pp. 313–316) first saw the gland in embryos of 5 months. It was about the size of the head of a small pin, spherical and pale. The brain sand did not appear until the 7th year.

Tiedmann (*89*–'16, p. 131) observed the gland in an embryo of 4 months as a small flat body, whose stalks connected with the optic lobes. During the next month the gland developed, but remained flat and without brain sand. Tiedmann did not study its structure.

According to Serres (*82*–'24–'28) the fundament of the pineal is paired. Over the mouth of the aqueduct in the 3rd month appear two small grey protuberances, which in the 4th month grow from before backward, and form the pineal. The gland has then anterior and posterior stalks; the anterior arising from the optic lobes, the posterior from the post-commissure.

According to Rathke (*73*–'39) the pineal arises from the pia mater.

Reichert (*74*–'61) was well aware of the processus pinealis in birds as described by Reissner, but he was unable to give anything further concerning its significance. He thought it probable therefore that the pineal was the outgrowth of the pia or dura mater.

Group II. This group brought the development of the gland into a closer relation with the roof of the 3rd ventricle and some authors also recognized the processus pinealis. Here belong v. Baer, Döllinger, F. J. Meckel, Remak, F. Schmidt, Kölliker, Balfour, and His.

V. Baer (*2*–'28) stated in his description of the roof of the third ventricle in the case of birds, that the optic lobes are united posteriorly by a delicate limiting membrane, which in part becomes the posterior cephalic commissure, but anteriorly is elevated and supplies the pineal. The pineal is therefore the roof of the fore-brain evaginated and afterwards arrested, just as the hypophysis is the degenerated point of the infundibulum.

F. J. Meckel (*56*–'15, Bd. I. p. 378) and Döllinger (*13*–'14, p. 16) have shown a similar limiting membrane to be the fundament of the pineal.

Remak (*76*–'55) says only a little concerning the pineal. A small protuberance arises on the roof of the mid-brain about the 65th hour in the chick, which becomes the pineal gland.

His (*35*–'68) also took this view, but without personal investigation.

We find the short statement also by Foster and Balfour (*20*–'76, p. 90) that the pineal gland arises from the small protuberance of the mid-brain on the third day of incubation.

F. Schmidt (*79*–'62) states that the roof of the mid-brain in the embryo of the ling is torn apart, excepting the posterior part situated in front of the mesencephalon which persists, and as a small bridge serves to unite the optic lobes. The bridge, by a transverse fold, forms the limits of the mesencephalon and bends posteriorly in the form of a cornet-like projection. In six to seven months the tip of the projection becomes a pineal gland.

Kölliker (*43*-'61, p. 240) corroborates the view that the pineal arises from the posterior undivided part of the diencephalon, and concludes with Tiedmann that the gland is first developed in embryos of four months, while its stalk can be recognized at three months.

Reissner (*75*–'51) indeed does not describe the pineal gland, but figures and describes the processus pinealis quite correctly in the chick, and thinks that the projection has the same relative position that the pineal has in the adult brain. Reissner was the first to correctly interpret the processus pinealis and described it as follows: In the first median vesicle of the brain there arises in front a very short process, whose cavity is joined to the cavity of the brain. Later it separates more and more. The place where the process arises corresponds to the place where the glandula conaria arises in the chick.

Balfour (*3*–'74) in Selachian embryos defined a small projection of the forebrain as the fundament of the pineal. (Plate XV, Fig. 15). It is noteworthy, inasmuch as it shows that the pineal is present in the oldest fishes and consequently is an organ early developed.

Group III. In this group of authors we find fuller discussions—Götte on the toad (Unke), Lieberkühn on the chick, and Mihalcovics on birds and mammals. The developmental relations of the pineal according to Götte (*28*–'75), are peculiar in the Batrachia. In the toad that part of the medullary tube which lies immediately in front of the mesencephalon closes last and remains in connection with the epidermis by a short solid bridge even after the separation of the tube. Soon an evagination of the ventricle pushes forward into the process, breaking its connection with the epidermis. The inferior part of the hollow projection is afterwards constricted forming a small vesicle lying over the roof of the diencephalon, to which it is joined by a solid stalk. Later the stalk lengthens considerably, and the cavity of the vesicle is filled up by the development of the cells. Finally, the cells are partly transformed into nerve cells; nerve fibres and a silvery white substance, are then developed, the latter being homologized with the brain sand of higher vertebrates. The pineal remains in very close relation to the epidermis. Its stalk is attenuated to a fine thread and becomes imbedded in the dura mater and the skull. Thus in Batrachia the pineal comes to lie on the outside of the skull chamber on the arch of the head. Further Götte (p. 316) remarks that this structure on the forehead of the toad was already discovered by Stieda, but was wrongly regarded as a parietal gland (Reichert's Archiv, 1865). All the remaining authors (Wyman, Ecker, Leydig, Rathke, Gegenbaur) who described the pineal of batrachians as situated in the skull cavity have confused the vascular plexus of the third ventricle with the pineal. Götte made no personal investigations concerning the gland in other vertebrates and only remarks that he cannot decide whether their gland corresponds to the entire pineal of batrachians or only to the basal portion remaining in the skull cavity; after some observations on birds and Selachians the first view seemed more probable. Finally he remarks that the pineal process cannot be considered as a simple evagination of the midbrain, for it is the last remnant of the union of the brain and the epidermis and the lack of this union may perhaps correspond to the cleft in the embryonic brain of the Amphioxus as described by Kowalewsky.

Lieberkühn (*50–'71*) first discovered the development of follicles from the processus pinealis in birds. He briefly describes the pineal process in a chick embryo of four days, then the diverticles in a goose embryo of 14 days, and says finally of a chick embryo of 9 days: Here the pineal appears as a large tube with numerous diverticles on all sides. Its structure is the same as that of the brain vesicle from which it takes its origin. A transverse section at this stage shows a cavity on the walls of which are small buds. The tissue of the skull capsule lies round about it. In a somewhat older embryo the buds have increased in number and the entire organ is more like the adult pineal gland.

Mihalcovics (*59*–'*77*) studied the pineal in chick and rabbit embryos and gave the following descriptions.

Situation of the pineal. The pineal gland (glandula v. glans pinealis, conarium v. epiphysis cerebri) in the adult brain lies in the falx cerebri, over the mouth of the aqueduct, and there on one hand is in connection with the connective tissue of the pia, and on the other with nervous structures, i. e. with the post-commissure and the pineal stalk. A short projection of the ventricle cavity which he has called the recessus infrapinealis, enters the gland. The above relations in fully developed organs point to some certain connection of the development with the roof of the third ventricle.

The pineal process. It has already been mentioned in the developmental relations of the diencephalon that the fundament of the pineal gland consists of a forward glove-finger-like projection of the roof-plate, which has been called the processus pinealis. In the chick the pineal projection begins to develop toward the middle of the fourth day and grows in the embryonic connective tissue over the roof of the diencephalon. In transverse sections the projection is circular and its wall consists of radially situated elliptical cells. Its length is .36 mm., diameter .09 mm. and the thickness of its wall is .018 mm. The whole projection is bent obliquely forward, its anterior wall entering directly into the middle of the vascular plexus, its posterior wall into the cerebral commissure, and the lateral walls in the fundament of the optic lobe region.

"*Epithelfollikel.*" In the chick the pineal projection retains the form and structure described up to the end of the fourth day. In the beginning of the fifth day numerous large blood vessels are developed over the roof of the mid-brain and surround the pineal projection with a network. Toward the middle of the fifth day small spherical diverticles grow out from the wall of the projection into the surrounding connective tissues and are forthwith constricted off as hollow spheres .02-.03 mm. in diameter. The constriction is brought about by means of the surrounding connective tissue. The number of vesicles constricted off at the end of the fifth day is limited, toward the sixth and seventh day it increases and surrounds the pineal projection in the form of a wreath, consisting of the same elements as the embryonic brain. The formation and cutting off of vesicles continues from the seventh to the twelfth days. Various large spherules (from .03 to .05 mm. in diameter) and funnels (.24 mm. long and .06 mm thick) surround the pineal process (which is 1.5 mm. long), where the larger diverticles arise through the later outgrowth.

Thus over the roof of the thalamus a club-shaped structure is found which stretches far into the connective tissue and is fastened to the skull roof by a thick connective tissue fibre at its enlarged end. Under the pineal projection, in the meanwhile, the adjoining roof of the thalamus has been drawn out to a funnel-formed appendage, which from its relation to the pineal gland has been called the recessus infrapinealis. The anterior wall of the projection is formed from a part of the middle vascular plexus, the posterior from the upheaved transverse lamella of the post-cerebral commissure, and the right and left lateral walls pass over into the optic lobe again. The cavity of the pineal projection remains present to the 14th day of incubation, then it decreases to an insignificant size, and this at last is changed to a vesicle. Up to the last day of incubation the vesicles retain their radial structure and connection of cylindrical cells, then they proliferate at the periphery into a layer of round cells, and the central cylindrical cells appear to have ciliated projections. The surrounding richly vascular connective tissue remains between the vesicles as the stroma of the adult gland.

The last changes consist in the contraction of the cavity of the recessus infrapinealis, by which a slender stalk is formed. The stalk arises by the approximation of the walls of the recessus, and consists in front, of the vertically upheaved part of the tela choroidea media and posteriorly of a narrow lamella, which projects from the post cerebral commissure to the pineal gland.

The gland of adult birds. The hemispheres of the cerebrum, and the cerebellum in birds are originally widely separated from one another and over the roof of the diencephalon and mesencephalon there is an abundance of connective tissue in which lies the pineal gland. But during their development the cerebrum and cerebellum would touch were it not for the connective tissue between them. At the same time the gland retains a kind of capsule from the surrounding pial-tissue. In fully developed birds the gland lies in a three cornered cavity between the anterior surface of the cerebellum and the posterior limit of the cerebral hemispheres. Its distal thick end extends to the dura mater and is joined to the latter by a stout filament. The gland consists of two parts, the gland body, and the stalk. From the development we have arrived at the necessary conclusions concerning the signification of each. In the stalk we find a continuation of the ventricle cavity, a remnant of the wide embryonic recessus infrapinealis which, through the approach of the cerebrum and cerebellum is pressed together. Anteriorly the stalk consists of a vascular plexus-like formation, arising from the epithelium of the roof of the ventricle, posteriorly of a nervous lamella proceeding from the post cerebral commissure and gradually thinning out. In the glandular bodies we find large and small roundish vesicles, also short funnels with a cavity filled with a liquid. The walls of the hollow bodies consist of high narrow cylindrical cells, then on the outside, round cells in several layers, between which the projections of the cylindrical cells can be traced, and finally the whole is surrounded by a thick connective tissue which forms a sort of capsule. The above described structures are best recognized in the turkey cock (Meleagris gallopara) where the entire gland is 5 mm. long, 2.5 mm. thick and the follicle has a size of .08–.20 mm. with a strong epithelium layer .04–.05 mm. The cylindrical cells of the follicle are .03 mm. high and the round cells .007–.008 mm.

Development of the pineal in the rabbit. The processus pinealis in the rabbit is developed as in the bird although in a relatively more hightly developed stage. The brain of a chick of 4½ days, corresponds to the embryonic rabbit 12–13 mm. long, although the first trace of a projection was found in an embryo 15–16 mm. long. The projection is considerably shorter (.15 mm.) and therefore is not bent so obliquely forward as in birds. It lies wedged in between the blood vessels of the corpus callosum. The constriction of the diverticles occurs in embryos 2 to 2.5 cm. long. The vesicles are as large as in the chick but their cavities are very small, hence the latter easily escape notice. The cavity then disappears entirely and all the cells become round or polygonal and are provided with shorter projections.

In embryos 3.5 to 4 cm. long the gland is pear shaped, its ventral aspect being in connection with the recessus infrapinealis while the dorsal end is closely united with the surface of the hemispheres. Later through the backward growth of the brain it becomes covered and lies under the corpus callosum in the fiss. transv. cerebri. The gland retains its connection with the diencephalon by remaining in connection with the post cerebral commissure, with the taeniae thalami by a nervous connection, on either side, and with the pedunculi conarii.

Histological structure. As to its histological structure the pineal of mammals in its embryological relations has suffered a significant deviation, in that the epithelium follicles have thrown off the vesicular form and the cylindrical cells have been transformed into round and polygonal cells. The development shows however that these cells are not lymph bodies. Neither can they be called nervous, first because they lack the necessary characteristics, and second because they are never found in connection with nerve fibres. As to their origin they are homologous with the epithelium cells of the ventricle and vascular plexus, and have undergone a metamorphosis similar to that of the epithelium cells of the enamel organ. Hence the whole organ is very similar to lymphatic connective tissue, although the development shows clearly that it is a fundamentally different structure.

Relations of the pineal in man. From the position of the pineal gland in the adult brain we can affirm with certainty that the human pineal develops in a way similar to that of mammals. The appearance of the pineal process in man occurs so far as comparative conjecture can ascertain, about the 6th or 7th week. The peculiarity of the human pineal is that it projects caudally over the post-commissure which may be due to the strongly developed callosal eminence. On this account also the recessus infrapinealis takes a horizontal position and the entrance to this diverticle of the third ventricle is not below but in front. Another peculiarity is observed in that the commissure of the pineal stalk embraces the pineal posteriorly and afterwards enters the epithelium of the tela choroidea media. At the transition lies a rudimentary nervous ridge (Taenia rec. pin., Reichert) similar to the taeniae medullares of the optic lobe. Through the above mentioned bend of the fibrous membrane there arises over the pineal, a second smaller diverticle of the third ventricle, called the recessus suprapinealis.

Stieda (*86*–'69) in his article on birds and mammals says: in birds the glandula pinealis grows in close proximity to the pia mater, with which it is usually removed. The so-called stalks of the glandula pinealis are so far as I have investigated them nothing but blood vessels. In horizontal longitudinal sections which cut the glandula pinealis transversely, I find one or two large blood vessels, cut transversely, in the mass of the pineal. From the pia which invests the gland proceed connective tissue septa as well as blood vessels, into the substance. Thus large and small reticular spaces are formed in which I see a delicate anastomosed structure, cells, and imbedded lymphoid bodies; between them numerous capillary vessels. I have not met with nervous elements. In mammals he found essentially the same relations as in birds.

In his article on amphibians and reptiles, Stieda (*86*–'75) again refers to the pineal: on the roof of the diencephalon rests a small roundish body, which stands in so close relation to the brain membrane that it is removed with it; this is the so-called glandula pinealis. In the same article under the caption "Das Epithel der Hirnventrikel und die Plexus Choroidei," he further describes the pineal and plexus: by the combination of the pia mater and the epithelium is formed the so-called plexus choroidei. There exists a plexus choroideus of the fourth ventricle, one of the third, and in close connection with the latter the two plexus choroidei of the "Lobi hemisphærici." There exists no distinct epiphysis cerebri (glandula pinealis) in turtles; the small cuneiform body which covers the third ventricle and roof of the diencephalon and is intercalated between the posterior sections of the lobi hemisphærici, is found upon microscopic investigation to be nothing other than the plexus choroideus of the diencephalon or of the third ventricle; nervous elements are wanting. It sufficies to say that the plexus does not lie immediately on the diencephalon nor on the third ventricle, but high above them. Farther cephalad where the third ventricle enters the foramen of Monro the plexus passes from the diencephalon into the unpaired ventricle of the forebrain and then passes laterally through the foramen of Monro into the lobi hemisphærici. In their structure all plexus choroidei are similar: they consist of folds or projections of the pia, which are covered with epithelium. Between the folds and in the projections of the pia are bloodvessels. The epithelium is in continuous connection with the epithelium of the ventricle; we see this most clearly in the fourth ventricle. The epithelium is always one layered; the cells are polyhedral and irregular, have a diameter of .015 mm., granulated protoplasm and round nuclei. The cells of the plexus have no cilia. Stieda describes the pineal of the mouse as surrounded with a connective tissue covering from which delicate septa penetrate into the interior, to form a fine network. In the meshwork of reticulum are found large, granulated, irregular cells, whose contour is very indistinct, so that the densely crowded cells are often inseparable and present the appearance of a uniformly granulated mass filled with scattered nuclei.

Miclucho-Maclay (*58*–'70) in his work on the selachian brain overlooked the diencephalon and identified that organ with the mesencephalon, thus introducing considerable confusion into the nomenclature of the fish brain. Stieda, however, showed that the position of the epiphysis is a fixed point serving to identify the diencephalic roof.[1]

Leydig (*49*–'72) who was probably the first to find the organ and give a detailed account of its structure, gives the histology of an organ which lies above the thalamencephalon or region of the third ventricle, but says that this organ is not the embryonic pineal which arises later and is of a very different structure. The specimens studied by Leydig were Lacerta agilis, L. muralis, L. vivipara, and Anguis fragilis. In L. agilis he found an organ which he called the parietal organ. Writing of this section he says that it could easily be taken for a sharply outlined part within the epidermis. The pineal gland lies in a direct line with the parietal organ in a transverse section. The relations in the parietal organ he gives in detail: 1. horny layer of epidermis; 2. mucus membrane with the organ imbedded within it; 3. the strongly pigmented portion of the cutis vera; 4. the bone which opens toward the surface. Beneath the bone lie the strongly pigmented meninges and under this the pineal, which is joined to the roof by means of two nervous peduncles. In Anguis fragilis he describes the organ as a dark spot, and the pineal gland as a dark streak. Of the epiphysis he says that its stalk consists of two peduncles, and lies below the spot and streak, and differs from both. Its surface has a folded appearance. The pineal is entirely unpigmented. As to the significance of the organ, Leydig thought it was related to the parietal gland of batrachians. Leydig[2] (*49*–'87) thinks that the parietal organ belongs to the system of sense organs of the lateral line, and finds a parallel in the luminous organs of certain fishes described by him.

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[1]Ueber die Deutung einzelner Theile des Fischgehirnes. *Zeitsch. f. wis. Zoologie*, XXIII.

[2]Fide Beard.

Rabl-Rückhard (72–'78) in his interesting paper on the Central Nervous System of Alligators gives the following description of the roof of the diencephalon: Posteriorly the roof is limited by the post-commissure and the elongated round conarium. The roof of the third ventricle is entirely membranous. As a transverse section shows, the vascular plexus of the roof proceeds over the dorsal limb of the optic lobes in a dorso-median direction to unite with an arch-like roof which lacks the ependyma and its highly developed plexus choroideus. In a longitudinal section we see that the roof of the corpora quadrigemina is somewhat thickened anteriorly. Joining this is a thin limiting membrane hardly as thick as the velum medullare anterius. This projects anteriorly and slightly dorsally and ends apparently in a knob-like thickening. This form in the longitudinal section arises from a transversely placed edge which bends around at right angles on both sides toward the front. The transverse section shows that the tela choroidea superior is attached to these edges throughout their entire length, while on the posterior part the conarium enclosed by these three edges lies in the groove which is open in front. This formation is thus properly designated as the taenia medullaris conarii. Whether the posterior transverse part is homologous with the peduncle conarii, he was not able to decide, as he could not determine the union of the conarium with it. Within, on the two posterior edges of the groove which are separated from one another only by the narrow fissure of the third ventricle, lies a tiny flat projection which is recognizable in spite of its diminutive size. A transverse section shows an elevation of the groove over the surface of the optic lobes and a corresponding arch in the projection. Rabl-Rückhard in his article (72-'85) gives the following summary: The pineal gland appears very diversely developed in the different families of fishes. In the salmon it has become a large gland-like funnel of the form of an elongated pear, whose narrowed stalk arises immediately in front of the anterior commissure, while the body (of the pineal) lies far in front on the rudimentary mantle of the fore-brain and buried in a groove of the frontal cartilage. There is an opening between the cavity of the pineal and the ventricle in earlier stages of development and also apparently in the adult brain of the salmon. In Cyprinoides (Leuciscus) the glandula pinealis appears as a flat cake which lies far in front on the Frontal, while the tubular stalk is enveloped by the plexiform boundary formed by the pia mater.

In (*72*–'86) Rabl-Rückhard calls attention to the fact that in his articles (*72*–'82) and (*72*–'84) he had arrived at the same conclusions that de Graaf presented in '86. In his article which appeared in 1884 he says: The skull-roof of the large fossil Enaliosaurians of the Lias, of the Icthyosaurians and of the Plesiosaurians, has an unpaired foramen which corresponds to the foramen in the parietal-bone of Sauriens. Perhaps here also lay the distal end of the highly developed pineal organ, and we could easily suppose its function to be not so much that of a visual organ, as a temperature sense-organ intended to warn its possessor of the intense effect of the tropical sunbeams, when it lay at rest on the shore and sandbanks like the present crocodiles. He says further that Leydig had expressed similar views in '72 and '81.

Huxley (*38*–'76, p. 29) writes: Dorsally the thalamencephalon is continued upwards and forwards into the subcylindrical peduncle of the pineal gland. This is a large heart-shaped body, whose base is turned downwards and backwards. The apex is connected by fibrous and vascular tissue, with a depression in the cartilaginous roof of the skull.

Beauregard[1] (*5a*–'81, No. 16, p. 233) says that the superior part of the diencephalon is composed of a little lamina slightly curved toward the anterior concavity separated from the posterior face of the hemispheres by a deep transverse cleft. The aperture of this cleft is closed by a transparent membrane in which is enclosed a little cordiform mass of opaque matter which appears to correspond to the epiphysis and is supported upon the posterior commissure of the two hemispheres.

Wiedersheim (*95*–'86, p. 181) says: Dorsally the dien-

[1] Fide Burkhardt.

cephalon is separated from the forebrain by a deep depression. It is nevertheless in connection with the pia mater by a membranous connective band, or a capsule, which arises from the edges and covers it. The significance of the capsule is not clear. On its upper surface was found a small opening which may have arisen naturally or artificially. The anterior steeply projecting part of the capsule, which in distinction from the rest appears opaque and thick, through a part characterized by its transparent appearance is united with the vascular plexus of the lateral ventricles and is histologically related to them. Up to the time that I had collected newer histological details I was satisfied to consider the organ to be the pineal gland, but after the removal of the membranous capsule I found a stout nodule directed upward and lying medially between the mesencephalon and diencephalon.

Henry F. Osborn (*64*–'83) made the following observations upon the brain of Amphiuma (Muraenopsis). The roof of the diencephalon is of irregular thickness; it is carried forward as a very thin lamina over the pineal gland. The structure of this body is nothing more than a rich plexus of bloodvessels produced from the choroid; in the apex are numerous fine nuclei, resembling those of connective tissue, certainly not of nerve-tissue. There is no evidence that the latter is present. It will thus be seen that the pineal body is a simple vascular structure, properly speaking, in communication with the brain cavity, since it is apparently surrounded by the brain parietes.

The same author (*64*–'88) described the characters of the roof of the diencephalon as very well marked. Just behind the supra-plexus are two oval or round swellings, which represent the ganglia habenarum with distinct median contours, but closely applied to each other in forms in which the supra-commissure is well developed, such as Menopoma, Amphiuma (Osborn '83 and '84, Fig. 4) and Axolotl (Fig. 1). Arching behind them and spreading beyond, into the thalami is a grayish band which probably represents the supra-commissure. This commissure underlies the pineal process, and is not seen upon the surface in Necturus (Figs. 2 and 8), but is apparently present in Proteus. Immediately behind this the whitish plates connected with the ganglia diverge, leaving a slit-like, oval or triangular space, in the center of which lies the proximal portion of the pineal stalk or processus pinealis. Close behind this a white or grayish streak represents the post-commissure. Upon the floor of this segment is an oval space, bounded by a whitish area which represents the recessus opticus, or proximal portion of the primitive optic stalk, which recess in Necturus and Proteus extends directly into the centre of the rudimentary optic nerve. There is a striking similarity, which may be merely superficial, between this area and that surrounding the processus pinealis.

In his paper (*64*–'88) Osborn does not describe, but draws the following relations in Rana mugiens and R. esculenta, Menobranchus, and Emys europaea; first, post-commissure, then pineal, supra-commissure, and plexus. In Rana the pineal arises immediately in front of the post-commissure, a segment of the roof intervening between the pineal and the supra-commissure.

Richard Kraushaar, (*44*–'84) gives the embryological de velopment of Mus musculus (white variety) and also a summary. He says: The epiphysis is developed from the forward projecting cavity of the processus pinealis which is composed of cylindrical cells. Its distal end is closed, while its proximal communicates with the ventricle of the diencephalon. The upper part of the wall of the processus which is thickened into a club-like form produces diverticles with small openings, by the intervention of the surrounding vascular connective tissue. At the same time the diverticle of the epiphysis is very much reduced and persists only in the lower part where the wall is very small and consists of cylindrical cells. Meanwhile the diencephalon under the epiphysis is drawn out to a funnel-shaped projection which is connected to its cavity. The so-called stalk alone retains the structure of the brain tissue.

Ahlborn (*1*–'84) discusses the nature of the pineal gland and concludes (1) from the correspondence between the optic vesicle, and the origin of the epiphysis from an evagination of the brain wall; (2) from the origin and connection of the epiphysis with the optic region of the brain, especially with the optic thalamus; (3) from the morphological similarity of the organ to a primitive optic vesicle; (4) from the similarity of the peripheral relations of the vesicles in selachians, ganoids, and Petromyzon, and from a peripheral position in amphibians outside of the skull on a level with the eye; and (5) from the primitive connection of the epiphysis with the nerve bundles (Van Wihje); that the glandula pinealis is the rudiment of an unpaired eye. He adds that if this view is correct, then the epiphysis as a rudimentary parietal eye is analogous in function to the unpaired eye of tunicates and perhaps also of Amphioxus.

Van Wihje[1] (*90*–'84) correcting his earlier statement that in selachians the anterior neuropore corresponds to the pineal gland, says that in birds the neuropore completely disappears in the stage with twenty-eight somites, and the rudiment of the epiphysis appears when twenty-nine somites are present.

Hoffmann[1] (*36*–'85) states that in representatives of nearly all classes of vertebrates the epiphysis arises as an evagination of the roof of the thalamencephalon.

De Graaf (*29*–'86) summarized his work on amphibians and reptiles as follows:

I. Amphibia. Material.—Siredon pisciformis, Triton cristatus, Triton alpestris, Triton taeniatus, Salam. maculosa, Rana esculenta, Rana temporaria, Alytes obstetricans, Bombinator igneus, Bufo cinereus, Hyla arborea.

(1) The epiphysis arises as a vesicular evagination from the roof of the thalamus where the latter joins the mesencephalon; at the place where it bends around into the roof it is constricted into a stalk.

(2) Shortly after its appearance the plexiform fundament of the plexus choroideus of the third ventricle is developed from the roof immediately between the epiphysis and the forebrain.

(3) In the Urodela the epiphysis becomes fungiform in the

[1]Fide Spencer.

later stages of its development and shows nothing peculiar beyond this.

(4) In the Anura, on the other hand, it becomes pear-shaped and grows forward. By farther development the vesicular tip is constricted off and comes to lie outside of the brain and later outside of the cranium; while the stalk-like end covered by the meninges persists within the skull cavity as the epiphysis.

(5) In adult animals the part of the epiphysis constricted off lies deeply imbedded in the cutis vera under the epidermis as Stieda's gland, becomes surrounded by a peculiar connective-tissue covering and shows a retrogressive metamorphosis in that it degenerates into fat.

(6) The very thin filament which in many cases joins the portion of the epiphysis which was constricted off with the spot lying between the ossa fronto-parietalia and was considered by Götte as the epiphysial stalk is nothing but a subcutaneous nerve, a filament of the Ramus supra-maxillaris N. trigemini.

(7) This filament generally runs in the manner mentioned. Occasionally, however, it comes from the region of the eye and ascends along the inner surface of the skin opposite to the extra-cranial part of the epiphysis; and sometimes it is wanting altogether.

(8) In the cases in which it ascends it ends in the connective-tissue capsule, never in the portion of the epiphysis in question.

(9) From the structure of the epiphysis of adults it can be determined with certainty whether a portion has been constricted off or not; in the former case it bends forward and ends in a point, in the latter it is fungiform.

(10) In Rana esculenta, Rana temporaria, Alytes obstetricans, Bombinator igneus, Bufo cinereus, we find the extra-cranial portion of the epiphysis present, while it is entirely wanting in the adult of Hyla arborea. The tip of the epiphysis running forward shows, however, nat in this animal a portion is constricted off in the embryological condition.

II. Reptilia. (11) The development of the epiphysis in reptiles is similar to that in amphibians.

(12) A more thorough investigation of the part of the epiphysis constricted off brought out the following: The structure in question lies between the meninges; it has the form of a round, more or less compressed, independent vesicle, and exhibits a cellular structure. The wall next to the parietal foramen is thickened into the form of a lense while the basal wall is pigmented on the interior.

(13) In Anguis fragilis the part of the epiphysis constricted off is also originally a vesicle, in which we can, however, later show a higher differentiation. The basal wall is composed of several layers, in the following order passing from within outward. First, a layer of very long, narrow cylindrical cells whose basal portion is completely imbedded in a deep black pigment. The part of these cells toward the cavity of the vesicle is perfectly clear and exhibits forms which by their refractive property remind one of the rod layer of the retina; their structure is not fully known. Then follows a layer of cells with large round nuclei which are imbedded in a fine granulated substance; and next to this at the periphery a layer of cells likewise bearing large nuclei that lie in two rows on the upper side. The entire lower wall becomes thinner as it arches upward and the continuity with the upper wall is completely interrupted, the latter is thickened into the form of a lens and consists of long, narrow, cylindrical cells, resembling more or less the embryonic lens. On this account the entire portion constricted from the epiphysis in Anguis fragilis resembles somewhat the eye of the more highly developed invertebrates, such as is known, e. g., in Cephalopoda, Pteropoda, and Heteropoda.

(14) The epiphysis in Anguis fragilis is very much twisted and its epithelium is ciliated.

(15) The fact that a part of the epiphysis which is constricted off and lies outside the cranium under the pia mater in Amphibia (Anura) comes to lie outside the brain below the parietal foramen in Sauria (Lacerta and Anguis) establishes, as the ontogenetic development has already shown, the homology of

the two structures beyond peradventure. If we recall, further that in the Stegocephala (Labyrinthodonta) from the Carboniferous, Permian and Trias, in Branchiosaurus gracilis Cred., B. salamandroides Fritsch, Peleosaurus laticeps Cred., Archegosaurus latirostris Jordan, Dolichosoma longissimum Fritsch, Acanthostoma vorax Cred., etc., an aperture is present in the parietal suture, which in its position corresponds perfectly to that of the sauriens of the present day, we are driven to the conclusion that the epiphysis in the progenitors of the present animals must have played an important role and perhaps has functioned as an organ of sense still unknown to us.

W. Baldwin Spencer (*85*–'86) in his interesting paper on the "Pineal Eye in Lacertilia," draws the following conclusions from his work:

(1) Our present knowledge is not great enough to allow us in Amphioxus, to homologize any structure either with the tunicate azygos eye or with the epiphysis.

(2) The epiphysis of higher Chordata is the homologue of the larval tunicate eye.

(3) The pineal eye is produced as a secondary differentiation of the distal part of the epiphysis.

(4) There is not sufficient evidence to prove or disprove the existence of the organ within the group Pisces; it was present in extinct Amphibia, and is found among living forms only in Lacertilia.

(5) In all forms at present existing it is in a rudimentary state, and though its structure is better developed in some than in others, it is perfectly functional in none.

(6) It was present most highly developed in (1) Extinct Amphibia (Labyrinthodonta), and (2) The large group of extinct forms (as Icthyosaurus, Plesiosaurus, Iguanodon, etc.) which may be regarded as ancestors alike of living Reptilia and Aves.

(7) The pineal eye may probably be most rightly considered as peculiarly a sense organ of pre-Tertiary period.

Beard (*4a*–'88) studied the parietal eye from the morphological standpoint and made the following important observations: In Ammocœtes he found black pigment in the parietal eye and showed that the arrangement of the rods and nuclei and cells of the retina of the parietal eye is essentially that of the same elements in the more perfect organs of Hatteria and Varanus, as described by Spencer. As in the adult the parietal eye of Ammocœtes is a variable organ—a point which is naturally of importance in connection with the question of its degeneration.

In Petromyzon planeri the external position of the organ is marked by a large whitish spot on the skin behind the olfactory hypophysial opening. In Petromyzon marinus it is especially large and, as in Petromyzon fluviatilis, the spot is due to the absence of black pigment over that portion of the skin. Corresponding to this white spot there is a depression in the cranium just beneath it. As this depression in P. fluviatilis is always associated with a fair development of the parietal eye in the individual, Beard assumes that the organ will probably be found well developed in the marine form as it is less degenerated than the fresh-water one. The same variation in the presence or absence of pigment found in Ammocœtes occurs also in fresh-water Petromyzon. Relatively to the brain the organ in the adult lies further forwards, and is connected throughout life with the brain by a somewhat long stalk. The parietal eye in the adult usually lies in a deep depression of the skull, but if no pigment be present in the eye, the corresponding depression in the skull is almost or entirely absent. The amount of pigment deposited in the eye varies in different specimens. The pigment referred to above is black. Beard did not find the white pigment seen by Ahlborn, nor the grey-white noticed by Wiedersheim, and therefore concluded that it was dissolved out in preparing his sections. In Petromyzon and Ammocœtes alike, the cavity of the vesicle is filled by a coagulable fluid. The posterior walls of the vesicle, or retina is made up of three layers : an inner layer of rods, which also contains pigment ; a layer of nuclei; and outside a granular striated layer containing a few ganglion-cells. Connective-tissue invests the whole eye. The end elements of the retina are of two kinds comparable to those in the retina of the ordinary eyes.

Beard studied one specimen of Myxine in which the structure of the organ in question could be well made out. The eye is a large flattened organ lying within the skull and connected to the thalamencephalon by a short, thick, solid stalk. The vesicle contained no pigment. The epiphysis in Myxine differs from that in Petromyzon in that it is not divided into two vesicles. Both anterior and posterior walls have the same structure.

The two forms Myxine and Bdellostoma are very closely allied, and in other points of great importance such as the structure of the teeth, they closely resemble each other and form a contrast to the Petromyzontidae, which while in some respects less degenerate than the former are in others less primitive. In concluding his article Beard calls attention to the fact that in Cyclostomata the parietal eye has all the characteristics of a degenerate organ, one especially in a very high degree, viz., its variability in different individuals.

McKay (*55*–'88) studied the development and structure of the pineal eye in Hinulia and Grammatophore and described the external appearance of the eye in embryos as follows : In the embryos of Hinulia which were advanced in development, the pineal eye could be seen standing out as a projection, at a point where the anterior joined the middle cerebral vesicle. The projection viewed as a solid object appeared to be composed of two lobes, an anterior larger, and a posterior smaller one. This appearance was explained when a longitudinal section of the head had been made ; the anterior lobe was seen to be the pineal eye proper, while the posterior lobe was the curved end of the epiphysis. In the advanced stages of Hinulia, the eye appeared as a black spot in the median line of the head posterior to the paired eyes.

Three stages in the development of Grammatophora muricata are described. In the first stage the epiphysis cerebri, composed of a single layer of columnar cells with well-marked nuclei, arises as an outgrowth of the thalamencephalon. In the second stage the anterior wall grows forward and forms a second evagination in the wall of the primary one. Thus we have two vesicles the anterior of which becomes the pineal eye. In the third stage the anterior vesicle becomes constricted off to form the pineal eye, while the posterior remains as the end of the epiphysis. The development of the eye of Grammatophora is somewhat similar to that of Lacerta described by Hoffmann, (*36*–'85).

In the stages of Hinulia studied, the eye was already differentiated from the epiphysis. Three stages were available. In the first stage seven layers were found in the retina as follows: (1) rods, occupying about one third of the whole thickness of the retina; (2) spherical nucleated bodies; (3) spindle shaped bodies, staining very deeply; (4) cells similar to the second layer; (5) spherical cells similar to the second and fourth layers; (6) a clear region; (7) a layer composed of round nuclei with much connective tissue. In some places the retina seemed to have a supporting network of connective tissue in which the different elements are imbedded.

The optic vesicle was found to contain minute strands. Ahlborn has described nervous strands in the optic vesicle which Spencer as well as McKay suggested might be nothing more than the coagulable remains of the fluid contents of the brain cavity. The strands that can be seen in the optic vesicle of the pineal eye of Hinulia and Grammatophora are identical with the fine strands in the cavities of the brains of both lizards. In the second stage pigment is deposited (1) in the lower ends of the rods, (2) in the line of spherical elements, and (3) in the lowest layer. Thus there is produced such an appearance, as de Graaf has described in Anguis fragilis, of a row of rods superior to the pigmented rods. The pigment is deposited in the rods as minute particles in horizontal lines, while it seems to be in vertical lines in the body of the retina. In the third stage the chief thing noticed is the further development of the pigment, which now covers the whole of the rods in many places; and where the lens joins the retina, the pigment reaches through nearly the entire thickness of the retina. It is also important to notice that the pigment is developed in the lens.

Throughout the three stages the eye is double-convex in outline, but the lens changes from concavo-convex to double-convex, and at first the optic vesicle presents a double-convex outline in section, which alters to concavo-convex.

In concluding his article McKay compares the forms which he studied and those described by Spencer, and gives the following points which are similar, or dissimilar:

(1) A scale is modified to form a cornea in Grammatophora, this being similar to such forms as Calotes, Varanus, etc.

(2) The lens is double-convex in outline, a point which appears to be common to nearly all the forms in which the eye is known.

(3) That the shape of the lens in the youngest stages of Hinulia is similar to the lens in Cyclodus, the eye in the latter being in a transitional state.

(4) As in some of the forms (Varanus, etc.) pigment is developed in the lens, so also in Hinulia slight pigmentation is present.

(5) The lens is composed of columnar nucleated cells.

(6) Retina. The columnar cells called rods are present.

(7) Nuclei are present in the rods in the later stages, a point not ascertained by Spencer in his higher forms.

(8) That the pigment is disposed in horizontal layers in the rods, and that where the rods join the lens the pigment reaches through the whole thickness of the retina.

(9) That a humour exists in the optic vesicle.

(10) That the rods have processes attached to the lower extremities.

(11) That spherical nucleated cells exist in Hinulia similar to those in Hatteria.

(12) That the molecular layer (if such it be) of Hinulia is placed in a very different position to the molecular layer of Hatteria and Varanus.

(13) That layers of spindle-shaped elements exist, which have no correspondence to any of the elements in Hatteria or Varanus.

(14) That layers of triangular-shaped elements exist which have no correspondence to anything in Spencer's form.

(15) That no such bodies as cones exist in Hinulia.

(16) That the epiphysis as in Calotes, Seps, etc., is separated from the eye, and that no such structure as the pineal stalk is present in either of the forms examined.

(17) That the eye may be supposed to draw its blood from the large vessel so constantly present directly beneath it.

Strahl and Martin[1] (*87*–'88). In Lacerta vivipara the stricture of the epiphysis to form the eye takes place in a different way from that described in Anguis. In Lacerta there is a simple evagination from the roof of the diencephalon, which is separated into two equal contiguous sections by a depression from above. In Anguis, on the other hand, nearly the whole primary evagination is changed into the eye and only the smallest remnant is left for the epiphysis. This remnant soon, however, changes its distal part by growth.

Francotte[1] (*21*–'88) described the pineal as a development from an optic vesicle which arises from a diverticle of the distal part of the cerebral part of the epiphysis. In describing the distal portion of the parietal nerve Francotte overlooked the proximal portion, a fact which is astonishing since he had an abundance of material. He supposed that it is attached to thc anterior surface of the proximal part of the epiphysis.

Johannes v. Möller (*60*–'90) states that only two papers have appeared on thc pineal gland of the chimpanzee, the one by

Marshall (*52*–'61), in which he merely states that the chimpanzee brain has a large delicate epiphysis without brain sand. The other is by Möller himself (*60*) where he describes the pineal as follows: The pineal, deeply imbedded in pial plexus which is removed from it with difficulty, lies in the furrow between the anterior pair of the corpora quadrigemina. Its form is such that we can distinguish first, an unpaired stalk which, with the pedunculi conarii branching from its anterior end, makes up by far the greater part of the pineal mass, and second, the samll nodule situated at the caudal extremity of the

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[1]Fide Klinkowström.

stalk. This last, perhaps 3 mm. in transverse section and 2 mm. in longitudinal section, is nearly reniform, since it is elongated dorso-ventrally, and shows a small invagination behind. The whitish-grey surface appears rough as if granulated. Sand is not present and was not to be expected in an animal so young. The stalk, over 4 mm. long, joined to the anterior part of the nodule is a structure composed of nervous tissue, which is also represented in a dorso-ventral section. At first small (hardly 1 ½ mm. wide) so that it is covered behind by the nodule, later the stalk broadens during its course forward and finally divides into two parts, namely, the two pedunculi conarii. These, as in man, pass over laterally on each side into the trigonum habenulae, while the unpaired stalk unites ventrally with the post-commissure. The inner attenuated edges of the peduncles terminate in the taeniae medullares of the thalami optici. The pineal recess stretches far caudad nearly to the nodule, i. e., the stalk is entirely hollow even to a small section of its hindermost part. This can be easily verified by the introduction of a bristle.

A second pineal of a young chimpanzee studied was not in a desirable condition as the caudal part was torn off. In it however this much can be established with certainty, that a similarly developed, hollowed, unpaired stalk of the same length was present. By means of Pal's method, the microscopic investigations brought out numerous well-marked longitudinal nerve fibres which, moreover, were not spread throughout the entire thickness of the wall of the stalk, but formed an outer continuous layer. From a comparison of the relations as found here with those found in man we obtain some noteworthy differences. The unpaired stalk which in the case of the chimpanzee pineal forms the principal stalk, is entirely wanting in the human pineal and in connection with it the pineal recess is more noticeable in every case. On the other hand the peculiar pineal body in man attains an essentially stronger development than in the chimpanzee, where the latter is represented only by a small nodule. It is moreover possible that the pineal body in adult chimpanzee attains a relatively greater development than in the young animal of which we are treating. Such a difference of development obtains in the case of the adult human pineal as compared with that of the child. Since the chimpanzee pineal by reason of the relatively greater development of an unpaired hollow stalk leading to the pineal body, approaches nearer the original form, it is justifiable to say that the latter shows a less rudimentary character than the pineal of man, provided of course, we here have to treat with constant relations. Whether such be the case, with the present meager observations cannot be stated with certainty.

A third pineal of a chimpanzee presented some peculiarities and digressions from the relations just described, so that they need a special investigation. There is such a reduction of this organ that it is practically absent. There is neither a trace of the pineal body nor of the unpaired stalk. The two peduncles appear as two small projections with their tips directed backwards, which, similar in size, are situated on each side of the posterior edges of the trigonum habenulae, and are united to each other by a narrow commissure. The latter forms the posterior projection of the taeniae medullares which blends here. The trigona habenulae moreover, in comparison with the first described cases, are very slightly developed since they are much less strongly arched and are not so sharply separated from the neighboring region of the optic thalamus. An explanation of this can be sought for in the defective development of the epiphysis itself, particularly in the stalk and peduncle, inasmuch as the nerve fibres of the latter, running over the ganglion of the trigonum habenulae to the taenia medullares, are here obviously reduced. The discussion then cannot concern the pineal recess, but on the contrary a very significant development of the recessus supra-pinealis which extends as a pouch-like evagination of the tela choroidea posteriorly to the middle of the anterior corpora quadrigemina. Here accordingly, not only its upper but also its lower wall will be formed of the tela choroidea, and not as in the other case from the upper surface of the pineal. Finally, Möller states that he found the pineal entirely absent in a human brain and adds that further evidence is wanted to show that the pineal in isolated cases is found in a greatly stunted condition or perhaps entirely wanting.

Hertwig (*3a*–'92) in his embryology made the following statements concerning the pineal: With the exception of Amphioxus lanceolatus the pineal gland is not wanting in vertebrates. It is always formed in the same way. According to Ehlers (*18*–'78) the pineal process attains in selachians an unusual length. Its closed end swells into a vesicle which penetrates the cranial capsule and extends out to the dermal surface. In many selachians, such as Acanthias and Raja, the vesicular end is enclosed in a canal of the cranial capsule itself; in others it lies between the cranial capsule and the conarium. In regard to the form of the organ there are three types; (1) In some reptiles, e. g. Platydactylus, the pineal has the structure found in sharks, i. e., a small spherical vesicle enclosed in the parietal foramen, lined with ciliated, cylindrical cells, and connected with the roof of the diencephalon by a long hollow stalk. (2) In other reptiles, e. g., Chameleon, the organ is differentiated into three parts; first, a small closed vesicle under a transparent scale, in the foramen parietale, lined with ciliated epithelium; second, a solid cord consisting of fibres and spindle-shaped cells, bearing a certain resemblance to the embryonic optic nerve; third, a hollow, funnel-shaped projection which here and there exhibits sac-like projections or enlargements. (3) In a third division of reptiles, e. g., Hatteria, Monitor, blind worms and lizards, the parietal organ resembles the eye of vertebrates. The portion of the wall of the organ lying next to the surface of the body has been transformed into a lens-like structure. The part of the wall lying opposite the latter and continuous with the fibrous cord has been converted into a retina-like structure. The formation of the lens is due to the transformation of the epithelial cells into cylindrical cells and uninucleated fibres producing an elevation, the convex surface of which projects into the cavity of the vesicle. The posterior portion of the epithelial cells is separated into different layers, the innermost distinguished by the abundance of pigment. Between the pigmented cells others are imbedded which can be compared to the rods of the visual cells in the paired eyes of vertebrates and which appear connected below with nerve fibres. It remains undecided whether the organ serves for sight or the perception of warmth. It is also undecided whether the organ is a structure developed as a special modification of the epiphysis of reptiles alone, like for example, the development of the tail in the crustacean, Mysis, or whether it represents a structure originally common to all vertebrates. In birds and mammals the pineal process undergoes metamorphoses which give rise to an organ of a glandular, follicular structure. In birds it never attains such length as in selachians and reptiles and it sends out cellular outgrowths which increase by budding and finally breaking up into numerous small follicles. The opinion has been expressed by many (Henle) that because the follicles are filled with spherical cells resembling lymph corpuscles, the pineal body is a lymph-organ. This has been refuted, for genetically the follicles are exclusively epithelial structures. In the adult, within the individual follicles are formed concretions, brain sand (acervulus cerebri).

Eycleshymer (*18*–'92) wrote as follows of the paraphysis and epiphysis in Amblystoma: In embryos of 5 mm. the epiphysis appears as a cresentic evagination in the roof of the thalamencephalon. The lateral walls are formed of several layers of cells, while the dorsal, which comes directly into contact with the superficial layer of the epiblast, has but a single layer. The nuclei undergo a marked migration toward the periphery. In this respect the appearance is strikingly similar to the conditions found in the optic vesicles which at this time are strongly evaginated. The presence of pigment at the inner ends of the cells is also a significant fact. From this time until the formation of the lens in the lateral eyes the epiphysis increases in size, its cavity becomes elliptical and is in wide communication with the thalamocoele. At the time of the invagination of the lens there appears in the posterior portion of the roof of the prosencephalon a second median outgrowth which is directly homologous with the paraphyses described in Reptilia by Selenka. Its walls consist of a single layer of cells, the outer ends of which are pigmented. In larvæ of 12 mm. the paraphysis is much elongated and lateral diverticles appear at its distal end, while the cavity is obliterated proximally in a manner analagous to that which occurs in the epiphysis. The changes are more pronounced in a larva of 14 mm., where the organ has assumed a digitate appearance and bears a striking resemblance to the true choroid plexus of the lateral ventricles. The two structures in Urodela never come into close relation, as in Reptilia, but remain widely separated. Leydig suggests the term "anterior epiphysis" for the paraphysis. The variation in the point of orgin of the paraphysis and its formation at a much later period than the epiphysis would seem to indicate a less important ancestral function. The phylogenetic importance of the epiphysis is certainly indicated by the fact that it is formed at a fixed point throughout the vertebrate phylum. Its ontogeny indicates that it arose at a time when a neural canal was first formed. If we admit the hypothesis, which I believe I have proved in Amblystoma and Rana, that the lateral eyes are present as a pair of depressions in the cephalic neural plate, we might suggest that at the phylogenetic period when they became implicated by the closing of the neural folds a median eye would arise and become most highly functional during the period in which the lateral eyes were non-functional or least functional. This might explain its unpaired origin.[1]

Burckhardt (*9*–'92) thought he had seen the pineal of Protoperus, but states that he had only a part of the pineal before him. He includes in the term tela choroidea superior, all the ependymatic forms of the diencephalon lying in front of the supra-commissure. Continuing his discussion he says: If we now consider the roof of the diencephalon in a perpendicular section, we find immediately in front of the post-commissure a little short, stout, but not always naked, ependymatic portion,

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[1]Compare with this suggestion the more recent articles of Locy (*61*–'93 and '94) and Prenant (*70*–'93). It is also interesting to note that in 1891 Professor C. L. Herrick made the same suggestion in a special course of lectures on Neurology delivered in the University of Cincinnati.

which thins out anteriorly. Next to this are repeated thickenings of the roof of the diencephalon which contain the supra-commissure. The pineal arises where these two sections meet. It consists of a corkscrew-like stalk which winds forward obliquely; its posterior part is hollow, while its anterior is solid. At the end, which is bent around horizontally, there is a pineal vesicle, a little glandular sack which is occasionally filled with sand. A communication of the cavity of the pineal stalk with the third ventricle is not shown, but such is possible. In front of the supra-commissure the roof of the diencephalon is elevated and forms by its walls a support for the pineal, hence this portion was called "Zirbelpolster," by Edinger. Then the roof bends down and forms the velum, a principal fold directed inwards, which produces other accessory folds. Here the epithelium arises again dorsally, among numerous plications and forms a primitive vascular plexus, for which I have suggested the term conarium; its anterior wall decreases anteriorly and passes in two diverging forms into the median wall of the fore-brain.

To sum up Burckhardt gives the following relations:

1. Commissura posterior.
2. Schaltstück (Pars intercalaris)
   Zirbel { a. Zirbelstiel.
   { b. Zirbelbläschen.
3. Commissura superior.
4. Zirbelpolster.
5. Velum.
6. Adergeflechtknoten (Conarium)
7. Plexus { a. Inferior et hemisphaerium sin.
   { b. Inferior et hemisphaerium dex.

The last four are included in the tela choroidea superior. ("Zirbel" of authors).

Comparative relations. According to the investigations of Ehlers, (*18*–'78), Edinger, (*16a*–'92), Rex, (*76a*–'91), as well as his own, Burckhardt found the following to be the structure of the roof of the diencephalon in selachians: anteriorly the mesencephalon descends obliquely and is limited by the post-commissure; then there is a segment of the roof in front of which the pineal arises in form of a funnel, which, with its knob-like end enters the skull roof. In front of the pineal is a transverse thickening traversed by the supra-commissure. In front of the supra-commissure the roof of the brain thins out into a superior tela choroidea, in which we can distinguish; (1) the "Zirbelpolster," (2) the Velum, directed into the ventricle as a fold of membrane, (3) an anterior segment from which (4) the plexus hemisphaerium descends. In front of this we find the fore-brain. If we now compare these relations with the foregoing relations in the roof of the diencephalon of Protopterus, it appears that the segment between the commissures is the same as in Scyllium. A complication, however, is encountered in the tela choroidea in that it is raised and forms a vascular plexus which has the appearance of manifold plications; likewise the lateral plexus inferiores appear in selachians as a segment of the tela. We have already seen that the velum in Protopterus has folds. The fore-brain which is two-lobed in Protopterus, has undergone in its median opening a strong constriction. Its median lamella is folded vertically to the tela and not horizontally. The elementary plications in the Protopterus brain are increased in amphibians. In the roof of the diencephalon of Ichthyopsis the segment between the post-commissure and the pineal has become somewhat extended; The pineal has abandoned its relation to the skull roof and forms only a small pear-shaped vesicle; the "Zirbelpolster" is elongated ventrally, and the velum has been transformed into an intricately ramified plexus choroideus, (ventriculi III), which reaches to the aquaeductus Sylvii. The vascular plexus (conarium) has become a complicated tubular system, whose anterior extremity lies between the hemispheres, while the posterior limit covers the entire roof of the diencephalon and envelops the pineal and "Zirbelpolster." The inferior plexus has also become ramified and enters the third ventricle, in which it lies close to the plexus inferior of the other side. The plexus hemisphaerium begins to descend into the first ventricle in front of it and not more medially, as in Protopterus. The ontogenetic development of the roof of the diencephalon accords with the phylogenetic, as it presents itself here. Let us summarize the characteristics of this brain region in Protopterus: A long stalked pineal which penetrates the cartilaginous roof, with its vesicle, a simple but slightly folded velum, a vascular plexus not yet differentiated into any particular organ, which together with the remaining tela appears from a superficial consideration to make a vesicular organ, plexus inferiores lying laterally. All these characteristics point to a close connection between the brain of Protopterus and that of selachians, while the degeneration of the pineal, and the differentiation of the vascular plexus into a particular organ, are points which together with the differentiation of the velum and plexus inferiores, and the elaboration of the roof segments, lend a peculiar character to the amphibian brain from Gymnophion to the Anura, and cause me to assume that their relation to Protopterus is more distant than that of Protopterus to the selachians. In concluding Burckhardt calls attention to the fact that the earlier brain-anatomists (and Gegenbaur in his text-book) considered the brain cleft ("Gehirnschlitz") the criterion for determining relations. We now know that the Gehirnschlitz is an opening which arises when through gross methods of preparation the interesting roof of the diencephalon is removed.

His (*35*–'92) from an examination of profiles of various embryonic brains shows that epiphyses may arise at more than two places. He says: The choroidal node found by Götte at the cephalic margin of the diencephalon in Amphibia belongs to the category of cephalic epiphyses. Here it is easy to distinguish them, as the difference between the two is very great. The epiphyis of selachians also arises from the cephalic part of the roof of the diencephalon. Later, however, almost the whole diencephalic roof is elevated and there results the familiar projection included between fore-brain and mid-brain, whose base extends caudad nearly to the post-commissure. Similar conditions prevail in teleosts. His also studied an epiphysis of the cephalic roof of the diencephalon in a human embryo 10.5 mm. in length. The roof plate forms at this stage a small median longitudinal ridge with two lateral angles. Cephalad this ridge is triangular and the median angle separates for a short distance as an independent appendage. When first discovered His thought that he had solved the history of the pineal and only a careful profile reconstruction revealed the fact that this body belonged to the very front of the roof of the diencephalon and seems later to disappear in the folds of the plexus. The true epiphysis, he says, develops much later, after the post-commissure is already formed, by protrusion of the most caudal part of the diencephalic roof. In the bird brain, as even Remak noticed, the epiphysis arises from the middle of the diencephalic roof and the same is true for the epiphysis of reptiles. Thus we distinguish epiphyses of the front, middle and posterior parts of the diencephalic roof. For the latter the name pineal may be usefully retained. Besides these special forms of outgrowth we encounter an elevation of the whole roof as in selachians and teleosts. Götte's "adergeflechtknoten" certainly pertains exclusively to the group of anterior projections while the so-called parietal eye of reptiles belongs to the middle group.

Studnicka (*88*–'93) wrote an extended article on the parietal organs of Petromyzon planeri which is here largely reproduced. His materials were: adult Petromyzon; Ammocœtes 23 mm. to 140 mm. long, also some more highly developed; embryonic fish eggs artificially incubated, from the stage of segmentation up to a length of 7 mm. Embryos from 7 mm. to 23 mm. long and the transitional forms between Ammocœtes and Petromyzon were not available. In his preparations Studnicka used chromic acid or sublimate for the embryos. For Ammocœtes and the adult Petromyzon good results were secured with ½ per cent. chromic acid; Müller's fluid and sublimate were used in some cases. Nitric acid (4 per cent.) was found to be of little value.

A. Embryology and Anatomy.

The pineal organ of Petromyzon is a simple evagination of the diencephalon behind the supra-commissure. Describing the evagination the author says in substance: At first this simple evagination inclines backward, later it grows in front until it inclines in this direction altogether. Its proximal portion always hugs the roof of the brain, while the distal portion enlarges upon all sides and takes the form of a hollowed vesicle placed immediately under the epithelium. At the point of its juncture with the brain the habenular ganglia are formed, that of the right side, which is more developed from the beginning, giving rise to the asymmetry of the superior wall of the brain which is inclined toward the left side. The pineal vesicle then lies lower on this side and deviates a little from the median line at the commencement of the pineal evagination. This probably depends upon the habenular ganglia which begin to form early, although it is not possible to infer from them the lateral origin of the pineal. The narrow proximal part in the form of a stalk at first unites the cavity of the pineal vesicle with that of the brain. When the distal portion of the pineal vesicle inclines more in front, the stalk also inclines forward so that several sections must be examined to follow its union with the brain vesicle. The opening of the stalk narrows considerably through the series. The opening of the pineal vesicle disappears almost entirely and its superior wall becomes attached to the inferior so that it is difficult to find the opening between them. In the subsequent development the opening appears again, the walls are separated and the vesicle alters its form. The stalk of the organ also assumes another form. Its orifice is obliterated and the stalk continues to lengthen, pushing the terminal vesicle ahead in front. Immediately after its formation, the pineal vesicle was behind the supra-commissure. In the embryo of 6 mm. long it is above the habenular ganglia, later it advances farther and farther beyond them. In a transverse series of a larva 26 mm. long the stalk of the vesicle does not lie at its posterior end, but a little in front. The part of the stalk nearest the vesicle has a narrow opening which passes in an oblique line from the nerve through the retina (the lower wall of the organ) and enters the cavity of the organ about the middle of the retina. This opening in traversing the retina is only visible by the radiating group of cells which enclose it.

The proximal part of the stalk is attenuated to a diameter of .009 mm., while the distal part nearest the organ containing the opening has a diameter of .03 mm. From its resemblance in development to the optic nerve and from its histological structure Studnicka gives to the stalk the name nerve; and as it belongs to the pineal organ he calls it the pineal nerve. Further this author observes that the pineal organ attaches itself obliquely to the ganglion of the left habena and also to the side of the right habena, uniting again with the latter at a point on the posterior part. The importance of this secondary reunion he does not indicate. The nervous filaments have not been traced from the ganglion into the organ, nor are ganglionic cells found in this part. In the case of younger embryos of 23 mm. long preserved in Müller's fluid, the pineal organ is completely detached. The reunion with the right habenular ganglion has not yet occurred, or possibly is already interrupted. This larva although smaller is apparently more developed. The reunion was already found in larvæ 7 mm. long. In case of other larvæ, although better formed, it is not yet found. The stalk is free, not reunited with the ganglion as in the case of those described above. In this example the reunion has been premature, being produced normally in larvæ 10 mm. long.

The Parapineal Organ. The origin of the parapineal organ was not found by Studnicka, as the vesicle was completely closed. In case of the youngest Ammocœtes studied (23 mm. long) the organ was laterally situated. Its walls were thin and it had a large cavity. In sections of larvæ 26 mm. long the parapineal organ was found to be no more developed than in larvæ 23 mm. long. The organ was found under the pineal organ which was a little inclined to the left but not so much as in larvæ 23 mm. long. The posterior portion is more lateral than the anterior as in the case of the pineal organ. The parapineal organ is not attached closely to the pineal organ, there being a narrow section of connective tissue with small nuclei between them. This tissue belongs without doubt to the cerebral coats. It is attached below to the superior walls of the thalamus. The anterior portion of this wall is thin but is not developed into the tela choroidea. This latter does not begin to appear behind, until a little later and that at first in the form of two simple elongated folds reaching to the sides of the inferior organ. The only place where it unites with the brain is at its posterior extremity where it is attached from above to the anterior extremity of the left habenular ganglion. The organ unites also in part with the right habenular ganglion as already remarked. Our author finds the union with the ganglion in the same sections of the series in which the pineal organ joins the ganglion. At the juncture of the organ with the ganglia the latter are found closely associated and touching each other. Immediately behind this place we see in the following sections nervous filaments passing from one into the other; this is the supra-commissure. Here our author remarks that it is an interesting fact that the epiphysis takes its origin in front of the post-commissure and the parapineal organ in front of the supra-commissure. The form of the parapineal organ resembles, in this stage, that of the pineal organ. Its anterior extremity ends almost in a point. The walls at this extremity are thin and composed of a single layer of cells. Farther caudad the inferior wall is much more developed and is thicker than the superior wall. What has been said of the form of the organ in larvæ 27 mm. long, applies also to its form in the adult fishes. The union of the organ with the right ganglion very soon suffers interruption, whereas that of the left remains. In longitudinal section it is attached to the anterior extremity and prolonged from the left habenular ganglion. In the case of more developed Ammocœtes this ganglion is still more prolonged and the organ pushed farther forward. The prolongation is made so that the more anterior part of the ganglion (Zirbelpolster, Ahlborn) is separated from the posterior part and does not remain connected with it. It is composed of a little bundle of nervous filaments. This little bundle is later prolonged and transformed into a slight nervous bundle. In case of the adult Petromyzon this commissure is very long and is recurved in the form of a semicircle. In the transverse section of this nervous juncture we find it very much flattened. It is more so in the older fishes and less in younger. It is situated directly in the tela choroidea of the third ventricle. Sometimes it is lost entirely in the tela choroidea and can easily pass unperceived. The difference between Ammocœtes and adult Petromyzon consists in this, that in the case of the latter the ganglion, placed under the organ (zirbelpolster), is larger.

Parapineal organ and Paraphysis. According to the concordant statements of authors the paraphysis takes its origin from the unpaired part of the cerebrum, and is distinguished by this, from the parapineal organ which has its origin in the thalamus. In adult fish one might easily confuse the parapineal organ which is found pushed considerably forward, with the paraphysis. Upon closer examination however, the paraphysis can be seen to be removed from the limit which separates the cerebrum from the thalamus. According to this author this limit is found in the place where the tela choroidea passes into the other thicker wall. In the case of adult fishes this place is marked by a sharp fold in the wall.

Coats of the Organs. The parietal organs are evaginations of the brain and are therefore enveloped with the same coats as the brain. At the point of the secondary reunion with the right habena the coats of the pineal organ are reabsorbed. At the exterior is found a strong shining membrane, the dura mater. Below this we notice the layer of fine filaments belonging perhaps to the pia mater. This author did not find any lymphatic cavities around the parietal organs.

The cornea of the parietal organs. At the surface of the head of Petromyzon planeri we see between the eyes a white region the size of a coin. It is caused by the absence of pigment under the corium. This pigment at first formed there a single superior layer visible across the (epithelial) layers of the skin, giving to the body a grey color. At this place the skin (epithelium and corium) is completely transparent. In the anterior part of this place a brilliant body of striking whiteness appears. It is the pineal organ, which is distinguished in its outline by a white pigment. In young Ammocœtes and adult Petromyzon the little transparent space is found well developed. In examining the brain from the superior side and paying attention to the pineal organs we find the skin attached to the intermediate part and connective tissue of the skull. In transverse sections of this region we find numerous filaments of this connective tissue uniting the corium to the skull. The superior wall of the skull above the diencephalon consists of a connective tissue transparent as glass, through which we get a glimpse of the brain, and especially of the habenæ and the white mass of the pineal organ.

B. Histology.

1. *The pineal organ* (*eye*). The first evagination of the pineal organ is composed of a layer of cells similar to ordinary embryonic cells of the brain. Later the composition of the superior and lateral walls shows a difference. The superior wall is always composed of a single layer of cells while the lateral have several. When the entire evagination takes the form of a vesicle provided with a stalk we can clearly distinguish 3 different parts: The distal part of the stalk which is the future nerve; the inferior wall—the retina; and the superior wall which always remains thin and occupies the place of the lens. This is the "pellucida." The nerve has at first the form of a hollow stalk whose walls are composed of one layer of cells. During the development the lumen is obliterated. In the tissue of the stalk which has still an embryonic character the white nervous mass begins to appear as nervous filaments, which are developed in the stalk. In a section made near the entrance of the nerve into the organ, among the numerous nuclei of the embryonic cells of the tissues of the stalk, two little colorless islands were found, representing, according to our author, nervous bundles. In a section taken later the nervous filaments occupy almost half of the stalk. In the proximal part the stalk is entirely changed into nervous filaments. The great resemblance which the development of the optic nerve bears to that of the pineal nerve is again confirmed by this discovery. It is necessary to count the pineal nerve among the cranial nerves. The numerous filaments were discovered in both transverse and longitudinal sections. They run through the nerve,

enter the retina and connect with its sensitive elements (rods). Besides the nerve-fibres, there are in this nerve scattered cells—the remnants of the primitive cells of which it was composed. These cells are also found in adult fishes. In the section studied some occur near the middle of the nerve, some at the periphery. A little bundle of filaments separates from the nerve, runs near to it and then reunites with it. This was found quite highly developed in a series of sections across the pineal organ of Petromyzon planeri. The nerve there was separated into three larger and three smaller, nearly cylindrical and mutually parallel parts. The beginning of the separation was not observed, but the union occurred quite near its entrance into the parietal organ. All the branches of this plexus attest a nervous character by their fibrous texture. Besides this, each branch is separately covered by an envelope of tissue, deeply colored, passing to the envelope of the organ. No common envelope to these nerves has been found. It is impossible to say what this separation might signify.

The Pellucida. The histological composition is very simple. In the embryos and in young larvæ it is composed of a layer of cubical cells. Later these cells become cylindrical. Their conformation is indistinct so that nuclei alone are seen placed upon the border and turned toward the opening of the vesicle. Further structure of the pellucida is generally indistinct in adult fishes. It has sometimes the character of connective tissue. In some places nodose thickenings were found inclined toward the opening of the organ; they are formed of elongated cells. Sometimes the entire central portion of the pellucida is thickened. The pellucida is in continuous connection with the lateral walls of the organ. Pigment was found in the pellucida, but solely in little groups of cells.

The Retina. In the superior wall of the pineal organ of embryos 5 mm. long, two kinds of cells were found, ordinary cells, having the form of embryonic cells, and among them others which have a more intense color and a more distinct contour. The form of the last is irregular but they are always elongated and placed vertically to the roof. Some of the cells are pyriform, with a sharp prolongation which is directed toward the inferior part of the retina. They resemble in a striking manner the embryonic ganglion cells. Embryos 6 mm. long have in the retina some cylindrical cells extraordinarily developed and vividly colored. They have the characteristics of the sensory cells of the sensory organs. At one end they terminate in a blunt point and at the other end they form a prolongation which can be followed even in the more inferior layers of the retina, where it is lost among other filaments which are believed to be nervous. It appears that in this stage a layer of nervous filaments is already found developed in the retina. As there are not at the same time nervous filaments in the stalk of the organ this would indicate that the filaments are developed in a centripetal manner. The sensitive cells mentioned are apparently the same as those described in the stage 5 mm. long, which here have an irregular form. They have the same peculiarities of form and susceptibility. In young Ammocœtes in which the pineal organ is still placed upon the frontal side of the head and inclined obliquely toward the base, upon the frontal side the elements of the retina are found cut longitudinally if the section has been made in a line parallel with them. In these we can follow the union of the elements of the retina with the nerve.

In Ammocœtes 30 mm. long the retina is fully developed and four layers are found.

1. Layer of nervous filaments. They pass directly from the nerve into this layer which is placed immediately above the envelopes of the organ.

2. Layer of basic cells. These are large cells, very distinct, with large nuclei, and colorless protoplasm. This layer is not easily distinguished from the preceeding and even here nervous filaments are present in part.

3. Layer of nuclei belonging to little cells.

4. Superior layer of cylindrical cells. These are of two kinds ; one, the rods ("batonnets"—a term employed by Francotte to designate similar cells in Anguis) are distinguished by distinct contours and by susceptibility to picro-carmine, hæmatoxylin, and methyl blue. These are without doubt the sensi-

tive cells of the organ. Their form in general is similar to those of young Ammocœtes. The superior part of the rods is a little thickened. In the inferior part is placed the nucleus, above which the cell is prolonged and is transformed into a nervous filament which passes across the inferior layers and grows into the layer of nerve filaments. This prolongation does not unite with other cells. Among these sensitive cells (batonnets) we find cells with oval nuclei which are not colored. These have no connection with the nerves. They are considered to be nutritive cells for the retina. The superior end of these cells turned toward the opening of the organ is bounded by a distinct line, above which our author believes that he finds vibratile cilia. This might, however, be a sort of coagulum of the liquid of the organ. There would be nothing extraordinary in the former conception, since all the retina has the same origin as the ependyma of the cerebro-spinal cavity, which has ordinarily a ciliated epithelium. The composition of the retina just described is uniform throughout. The rods are everywhere crowded and it is a very important fact that on the two sides of the entrance of the canal into the cavity of the organ the nervous prolongations of the rods are sometimes closely approximated. It seems that these rods unite in fascicles. On the sides and in the atrium the rods disappear. The thin vesicular wall is composed of cylindrical and round nutritive cells. Beyond this the walls are composed of indistinct cells. These slightly resemble the cells of the retina. Above the cylindrical cells a layer of nervous filaments is found traversing the atrium longitudinally and going from the nerve into the retina.

The cell structure in *adult Petromyzon* differs much from that in Ammocœtes. All of the cells of the layer of cylindrical cells are of the same form and these sensitive cells are like those in Ammocœtes. The other layers are similar throughout. Among the basic cells incontestable ganglionic cells were found. The difference between the retina of larvæ and adult fishes has not been recognized hitherto. The examination of the pineal organ in adults presents much more difficulty than in Ammocœtes by reason of the greater development of the pigment. At the exterior there is a layer of filaments, as in the case of Ammocœtes, in connection with the brain by nervous filaments of the stalk of the organ. In the layer of basic cells are scattered ganglionic cells which are more numerous at the extremity of the retina. Beard calls this the ganglionic layer. They can be considered as nervous from their form and susceptibility to stains. They are found in small cavities formed by a fine membrane (lymphatic cavities ?). Some prolongations appear to penetrate into the layer of nervous filaments. A single prolongation upward has been found. The third layer (nuclear layer of Beard) is composed of nuclei belonging to different cells whose shape it is impossible to follow. They are probably nutritive cells. The exterior layer is composed of perfect and equal cylindrical cells. These cells have the same significance as the sensitive cells in Ammocœtes. They have above the large end a hyaline point, or perhaps they form the delicate framework of the coagulum (?) of the hyaline body. They narrow at the end, while they enlarge where they contain the nucleus. Finally they pass into an arched nervous filament which is directed toward the base and backward toward the nervous layer. In the case of adults this union with the nervous layer has not been noticed, but we may suppose it. The union of several nervous processes into a single bundle, such as Owsjannikow figures, has nowhere been found. The apparent union is an entirely different thing. These cells, moreover, in Petromyzon differ in thickness from the sensitive cells (rods) of Ammocœtes. In Ammocœtes they have the form of thin rods, while in the case of Petromyzon they are sometimes pyriform. This thickening is probably due to pigment which penetrates their plasm and fills them, whereas in Ammocœtes the pigment is never present. They are easily stained, but only in their inferior part, where they contain little pigment.

Pigment. In the retina of the pineal organ of Petromyzon the pigment is of great importance. It is always white, the black being found only occasionally in the envelopes and in small quantities. Seen in the microscope the white pigment is quite black when viewed by transmitted light and in this case it is impossible to distinguish it from the black pigment. It is distinctly recognized, however, by turning the mirror and observing with the illumination from above. Then it is distinguished from that in the envelopes by its snowy whiteness. The pigment was found both in the cells and also intercellularly in the retinal layer, although this is a rare case. The pigment appears very late in the parietal organ. It was found only in larvæ 50 mm. long and in Petromyzon. Pigment was found in larvæ 6 mm. long but this had nothing to do with that found later filling the organ. This pigment reappears often in the tissue of the nerve centres of embryos. The youngest larvæ in which the white pigment is developed are 60 mm. long. Only little pigment is found there and this only with a high power. It is only in the highest developed Ammocœtes more than a decimeter long that a completely pigmented retina was found and this only in two out of five specimens examined. The specimens of Petromyzon examined had each its pigmented organ except one preserved in nitric acid. In Petromyzon it is more developed and thicker than in Ammocœtes, sometimes penetrating the entire thickness of the retina. The pigment is ordinarily diffused in the entire extent of the retina. Passing laterally it sometimes becomes rarer and disappears. From the retina it descends into the atrium and fills most of the posterior edge in entering it. It often passes into the nerve and fills it throughout its entire diameter, or it may only enter it scattered along the nervous filaments. In Ammocœtes the pigment was generally found in the cells, more rarely intercellularly in all the layers of the retina. The principal base of the pigment is composed of long cylindrical nutritive cells bordering the superior surface of the retina. In other cells there is less pigment. The sensitive cells (rods) in Ammocœtes sometimes do not contain pigment and are easily recognized in stained preparations, among the other pigmented cells. In Petromyzon all the cells contain the pigment which descends by fine nervous prolongations and which in consequence make the retina appear transversely striated. In the layers situated above the cylindrical cells the pigment is at times very diffuse. The cells thus filled by pigment have the appearance of black tufts or little balls; their nuclei are often invisible on account of the pigment. In the cells filled with pigment little distinct round or oval bodies appear. In this case the black color of the pigment disappears under strong magnification and they are then of a dazzling whiteness. They give the impression of little sand grains. These are the elements of the white pigment, if it may be so called. These pigment bodies are found in the plasm of the cells. Only the nucleus may be without pigment; sometimes they fill the cells entirely. At times the inferior part (in the cylindrical cells) remains non-pigmented; this occurs especially in the cells placed at the end of the retina which are only half filled with pigment.

Cavity of the pineal organ. In the youngest embryos the cavity is in direct communication with the cerebral cavity; later it is closed by the approach of the walls and only opens again after some time. In the cavity of the organ there are two kinds of structures; a delicate framework and peculiar little vitreous bodies. These two structures occur in both Ammocœtes and Petromyzon, but never at the same time. (1) The delicate hyaline framework spread about in the cavity becomes yellow or brown by the process of preparation. Its elements communicate with the pellucida among whose cells they end, and also with the retina where they are directly united with the sensitive cells. In Petromyzon their union with the retina could not be observed on account of the thickness of the pigment. They were found in 5 specimens out of 17 in Ammocœtes. In some preparations this coagulum was in the posterior part of the cavity. In this case the anterior part was empty. The significance of the union with the sensitive cells remains problematical. (2) The little vitreous bodies of the second form are attached to the interior of the cavity of the pineal organ, or they fill it entirely. In the retina of adult Petromyzon these little bodies were observed in connection with the cells of the organ. The retina there was covered with vitreous bodies like little drops of water. In some places these bodies were seen to arise directly from the cylindrical cells. It seems that the vitreous mass which these little bodies compose is secreted by the cells. In several cells which were considerably pyriform-inflated were found large colorless vacuoles. These vacuoles appeared to contain a hyaline mass which, excreted from the cells, attaches itself to the latter, assuming the form of little bodies. Upon closer examination some little bodies were found separated from the cells, others divided in several parts, and several perfectly free. In the case where the entire cavity was filled they undoubtedly had this origin. In the pigmented retina sometimes the pigment bodies penetrate in a larger or smaller quantity into these hyaline prolongations. The hyaline filaments sometimes leaving or starting from these little bodies are undoubtedly coagulum. The vitreous bodies have very little color in the preparations strongly colored with picro-carmine or eosin. They may be a pale rose color. They were found in preparations made in chromic acid, nitric acid and dilute Müller's fluid. Perhaps they serve to refract the light. The entire organ has no lens. These little bodies probably serve to supply the lack of a lens.

2. *Parapineal Organ.* The parapineal organ is always much less developed than the pineal organ but much more differentiated than Beard has found it. The superior wall is slight and composed of a single layer of cells. The inferior wall, the retina, is thicker, and is attached by its own center below to the separated anterior portion of the left habenular ganglion (zirbelpolster). The elements of the retina can be distinguished with difficulty. In some sections rod-like cells have been found, distinct in contour, strongly stained, and analogous to the rods of the retina of the pineal organ. Among the latter are found numerous nuclei disposed in several rows, belonging to smaller cells with various forms. Above the latter is a nervous layer united to the ganglion nerve fascicles. No union of the rods with the nerve was noticed.

3. *Central innervation of the parietal organ.* The nerve filaments have been followed after their entrance into the brain and even within the brain. They were lost sight of in the post-commissure. It is not decided whether the filaments traverse this commissure in entering the posterior part of the brain, or

whether they unite with it. The parapineal organ is innervated from the left habenular ganglion. The branch of the left bundle of Meynert also enters here.

Klinkowström (*42*–'93) gives the following summary:

I. Parietal eye.

1. The pineal eye of Iguana, arising from the constriction of the distal part of the primary epiphysial evagination appears on the ninth day as an oval vesicle more or less constricted off from the proximal epiphysis.

2. The originally strongly biconvex lens in the course of development takes a flat slightly biconvex or even plainly convex form.

3. From the 14th to the 18th days the entire inner side of the eye-cavity is covered with cilia. A strong nerve unites the under side of the eye-vesicle with the roof of the diencephalon. The retina shows two zones, one inner, without cells and an outer, cellular zone. Black pigment begins to appear on the retinal cells, and from the surrounding mesoderm, a connective tissue capsule surrounding the nerve and eye begins to be formed.

4. In 24 to 26 days the parietal nerve has reached its highest development. Through the inward (?) growth of the nerve-fibres the retina is divided into an outer and inner cell layer, between which the nerve can be seen as a thin fibre-layer. In the inner zone an abundance of pigment has been formed.

5. In 35 to 40 days the nerve and nerve-fibre layer show significant signs of degeneration. The pigment has largely increased.

6. In the adult Iguana the pineal eye shows the variations characteristic of rudimentary organs.

7. The nervous elements appear to have entirely disappeared in the retina and the formation of pigment has become so excessive that a recognition of the structural relations is often impossible.

II. The parietal nerve.

1. The nerve which enters the pineal eye is not similar in its development to the optic nerves of the paired eyes.

2. At the end of the 9th day there is still no trace of a nerve to be seen entering the vesicle already separated from the pineal.

3. By the 14th day the nerve is formed and passes from the floor of the eye-vesicle to a cell accumulation lying in the roof of the diencephalon, called the parietal-centrum.

4. The parietal-centrum lies asymmetrically to the right of the middle line, immediately in front of the pineal evagination.

5. In 24 to 27 days the nerve is surrounded by a connective tissue sheath (perineurium) and the parietal-centrum now lies in a direct line with the right ganglion habenulæ.

6. In 35 to 40 days the nerve shows undoubted appearances of degeneration that already appear to have produced atrophy of its central part.

7. In the adults the nervous elements are completely atrophied and only the thickened perineurium remains.

8. In one embryo of Iguana there are two parietal nerves, one from each ganglion habenulæ.

III. The Proximal Pineal.

1. At the end of the 9th day the pineal in Iguana has the form of a vesicle communicating with the third ventricle, which shows a structure comparable to the parietal eye vesicle.

2. In the course of development the pineal is covered with cilia internally and is gradually transformed into a long funnel.

3. The proximal part of the pineal retains a structure suggestive of the medullary tube, while the distal part has a development suggestive of the retina of the parietal eye.

4. The coniform pineal of adult animals retains in its distal end the funnel-shaped form as in embryos, while its proximal part undergoes a follicular transformation through the growth of the wall.

5. The epiphysial evagination in Tejus shows in its early embryology just as in Iguana, a constriction causing the division into a distal part (pineal-eye vesicle) and a proximal part (pineal).

6. Later this constriction disappears again and the entire primary epiphyial evagination is developed into a pineal.

7. The pineal in a stage corresponding to 24–26 days of Iguana, shows traces of pigment that appear to vanish again afterwards.

8. In an embryo of Iguana nerve bundles from the diencephalic roof, entirely similar to the parietal nerve, enter the posterior part of the pineal.

9. On the end of the proximal pineal of an Iguana embryo and in an adult a secondory pigmented pineal eye is developed.

Klinkowström drew the following homologies between Iguana and Petromyzon:

IGUANA.	PETROMYZON.
1. Parietal nerve.	1. Ventral eye vesicle.
2. Pineal eye and distal part of the pineal evagination.	2. Dorsal eye vesicle.
3. Proximal part of the pineal evagination.	3. Pineal stalk.
4. Right parietal nerve.	4. ——— ———
5. Left parietal nerve.	5. Left parietal nerve.
6. Parietalcentrum.	6. "Zirbelposter."
7. Post-pineal nerve.	7. Nerve filaments from the region of the post commissure to the dorsal eye vesicle.

Béraneck[1] (*5*–'87) in his first work, concluded that the parietal eye is derived from the primitive epiphysis. In his second work (*5*–'92) he described two stages of embryos of Anguis (15 and 24-27 mm.) in which the vesicle was already disconnected from the proximal epiphysis. In the two stages Béraneck followed the course of the parietal nerve from its origin in the roof of the diencephalon to its entrance into the retina of the parietal eye. Throughout its course this nerve presents the relations to the proximal part of the epiphysis described by Francotte. From the fact of the existence of a separate parietal nerve distinct from the epiphysis and connecting the parietal eye directly with the roof of the diencephalon Béraneck concluded that the parietal eye is not a diverticle of the distal part

[1] Fide Klinkowström.

of the primitive epiphysis but a special organ arising from a diverticle developed directly from the roof of the diencephalon, and is related to the epiphysis by position rather than by derivation. He denies the homology of the distal part of the epiphysis which forms a diverticle in *Cyclodus*, with the parietal eye of Lacerta, Anguis and other lizards, and also the homology of the pineal eye with the distal vesicle of the epiphysis of the selachians. In concluding Béraneck gives seven points of which the following are the first and fifth. First: The parietal eye cannot be considered as a simple diverticle of the pineal gland. In the case of Lacerta and Anguis it constitutes an independent organ which proceeds from the thalamencephalon like the epiphysis, but is developed parallel to it and not from it. Fifth: The epiphysis is derived from an evagination of the thalamus. It does not represent the stalk of the parietal eye. It is an organ sui generis, whose first funtions are still unknown. It does not reveal marked sensorial characteristics as in selachians where it is highly developed. The epiphysis appears to be continuous throughout the series of vertebrates and is phylogenetically as old as the parietal eye, for it appears as early if not earlier in the ontogeny. In Anguis Béraneck discovered a nerve entering the retina of the eye. Between the 9th and 14th days a nerve unites the eye to the roof of the diencephalon. In a later article (*5*–'93) Béraneck replied to Klinkowström's article of the same year (*42*–'93) and maintains that in Lacerta there are two diverticles from the thalamus, the anterior giving rise to the parietal organ, while the posterior becomes the epiphysis. He further states that in lizards the parietal organ is not derived from the pineal gland, while in Anguis fragilis it is so derived.

C. von Kupffer (*45*–'94), whose article did not reach me in time to give his description, figures the roof of the diencephalon in Ammocœtes planeri and shows the following relations:

(1) Post commissure. (2) Pineal stalk with ep.[2] attached. (3) Segment of the roof. (4) Supra-commissure.[2] (5) Segment of the roof. (6) Supra-commissure.[1] (7) Epiphysis.[1]

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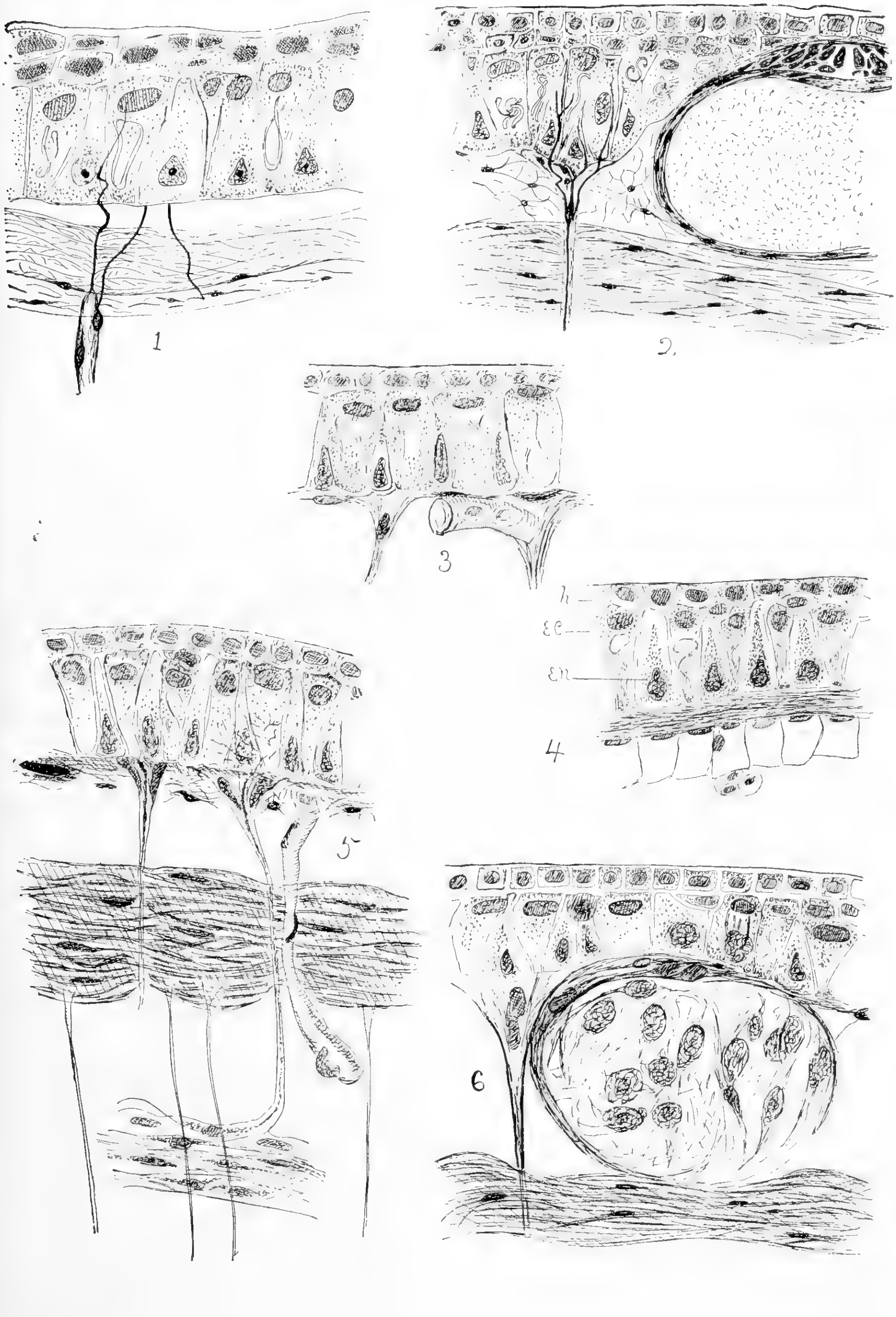
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ON THE BRAIN OF THE SNAPPING TURTLE, (CHELYDRA SERPENTINA.)

O. D. HUMPHREY.

(*With Plates II, III and IV.*)

With the exception of the numerous papers upon the parietal eye, the reptilian brain has not been so thoroughly studied as that of many other vertebrate forms. Why this should be so is not easy to determine, for the reptilian brain presents an attractive field for the morphologist. While it lacks the primitive structure of the amphibian brain; in it are found the first advances from the simplicity of the amphibian type, and the beginning of almost all of the structures that are found in the complex encephalon of the higher vertebrates. Instead of the simple tubular form found in the amphibian brain, with the cinerea lying closely about the central cavity, and nerves springing from poorly differentiated areas; we have here large groups of gigantic cells, great bundles of fibres that are somewhat susceptible to ordinary stains; strong commissural systems and well marked cortical areas.

The first mention of the turtle brain was by Carus in 1814, but the first study of it was made by Bojanus in 1819. Mauthus, in 1861, studied the spinal cord of the turtle with the aid of the microscope, and W. Müller, in 1871, made some observations upon the hypophysis. Stieda (85) was the first to make the turtle brain the subject of a monograph, and his work and figures are quoted and copied in many works of very recent date. Meyer gives a careful account of the forebrain in a recent paper (56). In this country Herrick has made many valuable observations on the turtle, as has Spitzka. Osborn has contributed to the knowledge of the commissural systems. Aside from these authors and short references in works of general comparative anatomy, the brain of the *Chelonia* has been little studied.

MATERIAL AND METHODS.

In preparing the following paper the aim has been to study the general morphology of the turtle's brain. While histological methods have been necessary for the study of parts that were too small and delicate for study by gross methods, no attempt has been made to give the details of histological structure. The material used consisted mainly of a number of brains of adult snapping turtles (*Chelydra serpentina*), collected during the summer of 1893, in western Indiana. To the Anatomical Department of Cornell University, I am indebted for some valuable embryo brains, without which my work would have been much less satisfactory. Acknowledgements are also due to Mr. A. T. Kerr, Jr., a student of Cornell, for some valuable material. In addition to this I had for comparative study specimens of *Chrysemys picta* and several specimens of the large sea turtle—*Chelone midas*—kindly furnished by the department. Prof. Wilder also generously put the large collection of reptilian brains in the University Museum at my command. These, containing as they do, many dissected preparations, were invaluable as a source of comparison for gross anatomy. I can only regret that lack of time rendered my work in this regard very incomplete and unsatisfactory.

Methods.—Various methods of hardening were employed. For adult brains potassium bichromate, zinc chloride, picric alcohol, Fish's alcohol-zinc chloride-glycerine method and alcohol were used. By the methods used for staining I found but little difference as to results except for the bichromate. Brains hardened in this did not show the cellular parts so well but were best for tracing the fibre tracts. For small turtles the skull was decalcified and sectioned. Embryos were placed in Perenyi's liquid for decalcification and hardening, and were then sectioned through the entire head. Sections of all forms were made in the three principal planes,—frontal, sagittal and transverse. All the preparations were imbedded in collodion and sectioned in Fish's castor-thyme oil mixture. This method has many excellencies to recommend it for nervous tissue. The stains used were hematoxylin and picric-acid-fuchsin. Experimentation with these gave better results than any other stains tried. Of the various hematoxylins, Delafield's formula gave the best results, though Gage's was usually satisfactory. The picric acid-fuchsin stain combined with the hematoxylin is especially good for work of this character, the hematoxylin staining the cells the characteristic color, while the fuchsin stains the fibers a cherry red and all connective tissues a very deep red. It was found that the following mixture of these stains would give as good results as to stain with them separately.

Sat. Aqu. Sol. picric acid	20 cc.
" " " Fuchsin	5 cc.
Delafield's hematoxylin	75 cc.

This mixture gives every indication of being permanent. Sections stained forty-five minutes with this mixture and allowed to bleach slightly in thirty-five per cent. alcohol, gave good results. A mixture with the hematoxylin increased to 100 cc. stains more rapidly. All figures were outlined with the Abbe camera lucida and details filled in with higher magnification.

ECTAL FEATURES OF THE BRAIN.

Cranial Cavity and Brain Membranes.—The cranial cavity of *Chelydra* is very large compared with the size of the brain, the latter in the adult occuping not more than one third of the space. This cavity is lined with a tough firm dura that slightly adheres to the bony walls and is carried out as envelope around the cranial nerves. The presence of this membrane renders the tracing of the cranial nerves through the thick walls of the skull comparatively easy, but makes the isolation of the separate nerve roots and branches difficult. Entad of the dura is the well developed arachnoid uniting the dura and pia by connecting threads. These threads are few in the cephalic regions of the brain but are especially numerous about the metencephal. The pia, compared with that of other animals, is tough and firm, adhering closely to the brain surface. Many minute blood vessels pass through the pia and deeply penetrate the brain. The close adhesion of the pia and the presence of these penetrating vessels renders difficult the removal of this membrane from the thin walled portion of the brain.

General Form of the Brain.—The brain of *Chelydra* as a whole, seen from the dorsal aspect, is very long in proportion to its width, the length being to the width as three and one half to one, measured in the maximum direction—i.e. from the cephalic end of the olfactory lobes to the caudal end of the oblongata, and directly across the cerebrum at its widest part. This ratio is greater than that in the brain of any other reptile that I have examined. Agassiz (1) gives the ratio of the length to the width of the brain in the Testudianata as about 2 to 1. The relative cephalo-caudal length of the segments, measured from the dorsal aspect is seen in the table below. The diencephal is not included as it is almost completely hidden by the overlapping cerebrum. The measurements fail to give the exact relative size of the parts, especially in the epencephal, as the cerebellar portion of this segment is sharply curved. The curve of the metencephal is not great enough to make much difference. The measurements are from an adult turtle, one with a carapace about 36 centimeters in length. At the suggestion of Prof. Wilder the relative length of each segment is given taking the mesencephal as the standard as it is the most constant in size of the segments and attains more nearly the same development in all forms.

BRAIN MEASUREMENTS.

	Length	Rel. Length	Width
Encephalon	32 mm.	5.3	
Rhinencephal	6 "	1.	5.3 mm.
Prosencephal	9 "	1.5	9. "
Mesencephal	6 "	1.	6.3 "
Epencephal	4 "	.66	4. "
Metencephal	9 "	1.5	6. "

From a lateral view (Fig. 3) the brain of the adult shows less flexure of the oblongata than is usual in *Chelonia*, and also shows its great length in comparison with its dorso-ventral diameter. On the dorsal surface, lying between the caudal portions of the cerebral hemispheres is a structure having a curved spindle shape. It is attached to the roof of the diencephal by a narrow stalk, from its attachment it enlarges, passes slightly cephalad and then tapers to a blunt point. It is closely wrapped by blood vessels and by means of these and some arachnoid threads is attached to a cartilage that lies against the roof of the cranium, from which the cartilage is easily detached in removing the brain from the dorso-lateral aspect. For this outgrowth as a whole, I can find no satisfactory name. It consists of three portions, epiphysis, dorsal sac and paraphysis. *Conarium* would be the most fitting term, but this has already been applied to the epiphysis alone, and Burckhardt (12) has further complicated matters by applying it to the paraphysis, in his paper on the brain of *Protopterus.* I have therefore used *dorsal outgrowth* to designate this structure as a whole. On the ventral surface, directly ventrad of the attachment of the dorsal outgrowth, is found the infundibulum. It has a conical form with the base attached to the ventral portion of the diencephal and the apex projecting caudo-ventrad ; to this apex is attached the hypophysis—a disk shaped mass, lying imbedded in a cup-like cavity of the cranial floor. These structures will be described at greater length subsequently.

SEGMENTS OF THE BRAIN.

Rhinencephal.—Although the olfactory lobes are usually not considered to constitute a segment of the brain, yet they will nevertheless be spoken of independently and not as parts of the cerebrum.[1] These lobes are well developed, their length being 60 per cent. of the length of the cerebral hemispheres. Their outline from the dorsal aspect (Fig. 1) is ellipsoidal with the greater transverse diameter near the cerebrum, the mesal aspects of the bulbs are closely apposed but not fused in any way. Each lobe contains a cavity, the rhinocœle, which is connected with the cavity of the corresponding hemicerebrum. From a lateral view the olfactory lobes approach the rectangular in outline (Fig. 3). Each olfactory nerve arises in two

[1]For a discussion of this question see Wilder (94) and Mrs. Gage (30).

bundles, one from the dorsal and the other from the ventral angle of the cephalic margin of the lobes. Between these roots the substance of the lobe curves slightly cephalad; the ventral surface is similar in outline to the dorsal.

Prosencephal.—The cerebrum of *Chelydra* is not well developed even for a reptilian type. From the dorsum the outline of each hemisphere is irregularly ellipsoidal. The mesal surfaces are closely approximated for their cephalic third but they divaricate caudad from that point. The caudal projection of the hemispheres overlaps and almost completely hides the diencephal from the dorsal aspect, and also slightly overlaps the pregemina. On the cephalic portion of each hemisphere, originating at the meso-cephalic margin, at the level of the dorsal surface of the olfactory lobe, is a furrow that extends latero-caudad around the lateral margin of the hemispheres. This feature I have not observed in any other reptile. From the lateral aspect (Fig. 3) the hemispheres have a broadly ellipsoidal outline. From this side is shown the slightly lobed structure of the hemispheres; the occipito-basal lobe of Herrick projects ventrad from the caudal portion of the hemispheres, overlapping from the lateral aspect the diencephal and the cephalic portion of the pregemina. These lobes are more distinctly shown from the ventral view (Fig. 2). From this aspect three ventral projections of the surface are shown. The general outline of the hemispheres from the ventral aspect is the same as from the dorsal, but the greatest lateral diameter of the cerebrum is a line passing through the hemispheres near their dorsal surface, the outline of a transection of the cerebrum being cuneiform with the apex of the wedge ventrad.

Diencephal.—The diencephal is almost entirely hidden by the overlapping cerebrum, nothing being visible on the dorsal surface, but the dorsal outgrowth, which has been described above and is shown in the figures. The ventral surface is formed mainly by the infundibulum, to which is attached the hypophysis.

Mesencephal.—The mesencephal is prominent in the dorsal aspect of the brain, the pregemina, as is usual in reptiles, being well developed being in the cephalo-caudal diameter about 60 per cent. of the length of the cerebrum. The general shape of the dorsal portion of each pregeminum is sub-hemispherical, resting upon its plane surface with the convexity dorsad. The two gemina are separated by a deep furrow, making the dorsal wall of the mesocœle very thin along the meson. The cephalic limit of the mesencephal is strongly marked on the dorsal surface by a transverse furrow. The basal portion of the mesencephal, upon which the hemispherical parts of the pregemina rest, projects caudad beyond the pregemina. At either side of this projection is a small tubercle raised slightly above the general surface (Figs. 1, 5, psg). These tubercles I have homologized with the postgemina. Between these postgemina the caudal projection of the mesencephal is convex caudad, this convex surface is furrowed on the mesal line (Fig. 1). This forms two small projections that I have homologized with the "inter-optic lobes of Spitzka. That author first describes them in *Iguana* (78) and speaks of them as "a concealed mass" in turtles. I find these to be quite prominent in the chameleon. The optic nerves have their ectal origin from the cephalic and lateral aspects of the pregemina from which origin they pass ventro-cephalo-mesad in a broad band lying close about the infundibulum, immediately cephalad of which they decussate, forming the chiasma.

Epencephal.—The cerebellum in its general shape is plate like with the convexity cephalo-dorsad. Its base rests upon the brain stem caudad of the mesencephal, from which attachment it arches dorso-caudad (Fig. 3). To its caudal extremity is attached the metatela. No pons can be distinguished and consequently no sharp division between epencephal and metencephal can be made.

Mentencephal.—This segment unlike the others has a roof entirely membranous. If this roof be removed we see from the dorsal aspect the wide cavity of the metacœle (Fig. 1). This appears as if formed by the spreading apart of the walls of the dorsal furrow of the myel. From the caudal portion the cavity widens gradually, reaching its maximum width ventrad of the caudal end of the cerebellum, from which point it contracts rapidly and passes under the base of the cerebellum as the narrow aqueduct. In the floor of the mesocœle, in its cephalic portion is a well defined mesal furrow with a slight ridge on either side. Passing caudad these ridges gradually sink to the level of the metacœlian floor until at the caudal portion they entirely disappear. The floor of the metacœle is approximately flat.

The membranous roof of the metacœle is much convoluted and folded upon itself. Fig. 5 shows the dorsal appearance in *Chelydra* and Fig. 7 shows its appearance from a mesal view in the sea-turtle, *Chelone midas*. A more exact description will be found in pages following.

THE CRANIAL NERVES.

In the study of the ectal features of the brain no attempt has been made to trace the peripheral course of the cranial nerves. The only object has been to locate their ectal origins and trace their course into the bony walls of the skull.

I. *Olfactories.*—In *Chelydra* each olfactory nerves arises from two roots, one from each angle of the cephalic margin of the olfactory lobe (Fig. 3). The fibers of these roots are distinct for some distance. They then approach and with the fibers of the opposite side are united into a common trunk which extends to the nasal cavities where the nerves separate and their fibers spread over the cartilaginous lining of the nasal cavities. In *Chelone midas* the origin is by three roots from each bulb, the third root springing from the lateral surface of the cephalic margin midway between the larger roots.

II. *Optic Nerves.*—The optic nerves have their superficial origin along the lateral and cephalic margins of the pregemina. Thence they extend cephalo-ventro-mesad around the base of the infundibulum cephalad of which they decussate forming the chiasma. From thc chiasma they extend cephalad, lying near together, until ventrad of the rhinencephal where they turn sharply ventrad and laterad to either eye. They are sometimes of seeming greater length than is necessary and are folded upon themselves. This same condition was found in the sea turtle.

III. *Occulo-Motor Nerves.*—These originate near the mesal line of the ventral surface ventrad of the central portion of the pregemina (Fig. 2). They run cephalad in a slightly diverging course, within the cranial cavity, until opposite the junction of the cerebrum and olfactory lobes where they pierce the dura and pass farther cephalad until they reach the eye socket into which they pass dorsad of the optic nerves.

IV. *Trochlearis Nerves.*—This pair is quite small. It takes its origin near the mesal line on the caudo-dorsal margin of the mesencephal (Fig. 1). Each nerve passes latero-cephalad around the geminum and then is carried forward until about opposite the cephalic third of the cerebrum where it, like the third pair, pierces tne dura and continues forward in this membrane until it passes into the eye socket.

V. *Trigeminus Nerves.*—This pair springs from the metencephal ventrad of the central portion about the middle of the dorso-ventral diameter (Fig. 1). Directly after it emerges it forms a ganglion, Gasser's, which is not so prominent as is usually figured in other classes of vertebrates. From this ganglion it passes immediately into the skull.

VI. *Abducens Nerves.*—These are very small. They originate near the ventral furrow ventrad of the origin of the 5th nerve (Fig. 2). Diverging they pass ventro-cephalad and pierce the base of the skull.

VII. and VIII. *Facial and Auditory Nerves.*—These originate as a common trunk a little caudad and slightly dorsad of of the 5th pair (Fig. 1). They pierce the dura and enter the skull as a common trunk, but this trunk quickly divides; the caudal branch subdividing enters the auditory capsule, while the cephalic portion also divides and its caudal branch passes into the auditory capsule while the cephalic branch extends peripherad as the true facialis. In *Chelone midas* these nerves orginate as two roots a small root arising directly ventrad of the main root but joining it at once.

IX. *Glosso-Pharyngeal Nerves.*—This pair originates a short distance caudad of the 8th nerve as slender trunks. These trunks pass laterad and pierce the dura and skull directly. Their course on first entering the skull is along the caudal margin of the auditory capsule, in the cartilaginous walls of which they lie imbedded.

X. *Vagus or Pneumogastric Nerves.*—These arise as three bundles of fine fibers along the lateral wall of the oblongata at nearly the same level as the origin of the 9th pair. An apparent individual variation exists in the number and arrangement of the tiny fibers that go to make up these three bundles. These bundles pass almost directly laterad and unite into a common trunk as they enter the foramen. After a short course this common trunk unites with that of the 11th and will be traced under that pair.

XI. *Spinal Accessory Nerves.*—Each nerve of this pair originates by six roots (Figs. 1, 2). The most cephalic root lies at the same level as the tenth, the caudal roots gradually approach the dorsal margin, the most caudal lying far dorsad. Another peculiarity in these roots is their wide cephalo-caudal distribution, extending from near the middle length of the oblongata into the myel beyond the first pair of cervical nerves. These six roots form a common trunk that enters the same foramen as the tenth. These two trunks lie close together wrapped in a common envelope of connective tissue, but do not unite until they have passed some distance into the skull (in Fig. 2 they are shown widely separated but in nature they are close together). Directly after their union they form a small ganglion. A short distance peripherad of this ganglion they are joined by the 12th nerve.

XII. *Hypoglossal Nerves.*—Each nerve of this pair originates by three roots from near the ventral furrow ventrad of the cephalic roots of the eleventh (Fig. 2). I find a very noticeable individual variation in the relative size of each bundle and in the number of separate threads that go to make up each particular root. The two cephalic roots may unite before they leave the skull or the most cephalic may be very small or entirely absent. The most common form is shown in the figure. In this three roots are found of nearly the same size, which do not unite until they have passed almost through the cranial wall. They then unite and join the common trunk of the 10th and 11th nerves.

The arrangement of the nerves in *Chelone midas* and *Chrysemys picta* is very similar. It differs greatly from that shown by Osborn (63) and Fischer (25) in the Amphibia, and also in some respects from that shown by Herrick (37) in the alligator and Owen (64) in the Python.

METENCEPHAL.

The Lophii and Sulci of the Metencephal.—In her paper on the brain of *Diemyctylus* Mrs. Gage (30) calls attention to the existence of furrows and ridges on the ental surface of the different parts of the brain, pointing out their number in the metencephal, and their apparent definite positions and relations. To these furrows and ridges she applies the name of *sulci* and *lophii.*

In the turtle these ental lophii and sulci in the metencephal are very noticeable. They are of two kinds the first, or primary, those involving a large portion of the wall of the metencephal, giving the general contour to the transections of that region, and the secondary, those that involve only the endyma and the subjacent thin layer of neuroglia. In the present discussion the primary only are considered. It is also noticed by the same author, that the position of the nidi of the metencephal has an apparent relation to the position of the sulci.

Observation of the internal structure of the metencephal has led to the belief that the sulci and nidi have no mutual relation, but that in the process of development the force that formed the sulcus at the same time determined the position of the nidus.

A transection of the caudal part of the oblongata (Fig. 8) shows a structure similar to that of the spinal cord. The H-shaped form of the cinerea persists. The alba, consisting almost entirely of longitudinal fibres, is collected in the four regions between the horns of the cinerea. These fibrous regions will be designated from their position, the dorsal, ventral and lateral columns, and no attempt will be made to trace the separate tracts; for, while an individual tract may vary considerably in size and direction in its course through the oblongata, the integrity of each column is, on the whole, maintained. In this section (Fig. 8) the metacœle shows as three small openings not connected with either the myelocœle or the dorsal furrow. Figure 9 shows a section a short distance cephalad of that in figure 8. In this the three small diverticles of the metacœle have blended into one cavity, while the metacœle is joined ventrad, by a narrow slit, with the myelocœle; dorsad the dorsal furrow widens and the metacœle is roofed in by a narrow tela. Little change is shown in the relative shape and relations of the various parts. The lateral projections of the metacœle become noticeable. A section a short distance cephalad of this (Fig. 10) shows the widening of the dorsal furrow and the formation of the broad metacœle. The dorsal cornu of the cinerea is encroached upon by the dorsal and lateral columns. The dorsal columns take a more horizontal position by the elevation of their mesal borders and project over the metacœle as the ripæ, while centrad of this ridge marking the point of union of the convex columns (as pointed out by Rabl-Rückard (67)) is a sulcus. Along the mesal portion of the lateral columns small bundles of longitudinal fibres have pierced the cinerea, forming the beginning of the reticular area. These reticular areas are formed along all sides of the cinerea, as we proceed cephalad, and seem to be the way in which the longitudinal fibers encroach upon and obliterate the gray areas. Farther cephalad a section (Fig. 11) shows a decided shortening of the ventral cornu with a corresponding progression of the lateral columns ventro-mesad. The dorsal column shortens in its lateral diameter and thickens in the dorso-ventral, encroaching upon the dorsal cornu and forming a reticular area in that region. The ventral columns are forced a little dorsad, elevating the floor of the metacœle, making it approximately horizontal. These columns are now clearly recognized as the posterior longitudinal fasciculi. The reticular area formed by the lateral column and the ventral cornu has greatly increased. Passing again cephalad (Fig. 12) we see the same process continued. The dorsal column is still changing shape, its mesal projection is less prominent and the sulcus consequently shallower. The dorsal cornu is represented only by a reticular area. The lateral column has crowded the ventral cornu mesad from its natural position until the reticular processes blend at the raphe with those of the opposite side; a nidus is formed at their junction. The posterior longitudinal fasciculi are separated completely from the lateral columns and have passed still farther dorsad, elevating the floor of the metacœle and forming a wide shallow sulcus on either side. Fig. 13 shows a section still farther cephalad. In this the main relations of the parts are as in Fig. 12, although the shifting process is carried still farther. The lateral border of the metacoele has become straightened, with a slight lophius (Sulcus *a*, Fig. 13) near the dorsal margin, formed by a division of the dorsal column and the mesal projection of the dorsal portion. The cinerea is still further limited in its area while the reticular areas are greatly increased. From this section cephalad until the region of the auditory nerve is reached no special difference in the relation of parts is to be noticed. The shifting of parts is continued, the small sulcus and lophius at *a* Fig. 13 disappear. The area of the cinerea is lessened and the portion representing the ventral cornu is pierced by a bundle of transverse fibres. In the region of the 8th nerve (Fig. 14) the lateral walls of the metacœle are thickened and brought nearer together making the sulcus at either side of the posterior longitudinal fasciculus narrower and deeper, while the furrow between these two bundles has deepened. The region of the lateral columns becomes massive and the reticular areas are slightly reduced. A section at the origin of the fifth nerve shows the lateral walls thinner; the region of the lateral column retains its massive character, while the entrance of the numerous fibers of the 5th nerve into the lateral part of this massive region gives rise to a projection of the lateral surface at that point

(Fig. 15). Two large nidi are seen at *ni. a*, and *ni. b*, in this section. The position of nidus *a* shows an apparent connection with the sulcus centrad of it, but the position of nidus *b* shows no connection with any sulcus whatever.

Conclusion.—The structure of the metencephal traced cephalad shows only such changes as would naturally result from a change of form from the tubular myel to the widely opened oblongata. The dorsal portions first proceed laterad and then ventrad, while the lateral regions move ventrad and mesad, and the ventral columns move dorsad and project as ridges, or lophii, into the cavity of the metacœle. Between these lophii, or projecting fiber tracts, are found the primary sulci formed by the meeting of the convex walls of two fiber tracts. It is also between the fiber tracts that the cinerea is found and observation shows that the form and position of the areas of cinerea depend upon the position of the columns, and as the nidi of the nerves are developed in the cinerea, they seem to have a relation to the sulci, but the development of nidi in regions remote from the sulci shows that the relation is only incidental.

Along the mesal line of the floor of the metacœle was found a projecting ridge of neuroglia, (Figs. 10–14). This ridge originates cephalad of the caudal portion of the metacœle and extends cephalad to the region of the 8th nerve where it forms a slight projection into the mesal furrow of that region, (Fig. 14). Through its entire length the endymal cells covering it, are of a slightly modified character. This ridge probably has no morphological significance as it involves only the neuroglia.

A section of adult myel about 3 cm. caudad of the closing of the metacœle, shows the ventral furrow extending to the ventral commissure of the cinerea. Tracing this furrow cephalad we find the raphe beginning to form at the mesal point of the ventral commissure. The raphe gradually increases in length as we pass cephalad, until the region of transition of the cord into the oblongata is reached, where the furrow is reduced to a shallow mesal depression. The most caudal of the same sections shows the almost entire obliteration of the dorsal furrow, it being marked externally by a very shallow groove. The floor of this groove is a thin crescent of neuroglia connected with the central cinerea by a very thin neuroglia column. Caudad this crescent and column disappear. Tracing these structures cephalad we find that they increase in area as the dorsal furrow deepens. This increase is especially marked in the width of the neuroglia column. As the furrow increases in depth the column is lost in the general cinerea of the central region. As the dorsal furrow deepens the pia follows it closely until it joins the endyma, where the furrow widens at the formation of the metacœle.

The metacœle is continued caudad in the form of short pockets beyond its union with the myelocœle and the closing of the dorsal furrow. These pockets vary in number, depth and form in different individuals. Fig. 8 shows a transection of this region across three of these pockets. I believe two to be the normal number, the mesal one not being present in all the specimens examined. The fact of the continuation of the metacœle caudad of the blending with the myelocœle is constant in the adult specimens observed. The union with the myelocœle and dorsal furrow is in nearly the same dorso-ventral plane.

The Roof of the Metacœle.—The great cavity of the metencephal has a membranous roof—the metatela. This roof is composed of a thin membrane formed, as are all the membranous walls of the brain, of a single layer of endymal cells and a layer of pia. In the embryo turtle this membrane is greatly convoluted and hanging down occupies the greater part of the cavity of the metacœle. At this stage the cavity is not so long, owing to the flexing of the metencephal almost upon the cerebellum. The metatela is attached to the dorsal and lateral edges of the cerebellum and to the metencephal along the margin of the entire metacœle. The folding of the metatela to form the metaplexus occurs just caudad of the cerebellum. In the embryo and in the young turtle, i.e., one with a carapace of 12 cm., this plexus is composed of foldings of the thin membrane. This membrane is at this time made up of a single layer of endymal cells and a thin layer of pia (Fig. 16). In the adult turtle the appearance of this membrane changes. To the unaided eye it has the appearance of being ridged. These ridges radiate from a common center on the dorsimeson. Caudad of these ridges the membrane becomes smooth and very delicate (Fig. 5). The appearance of this membrane in the great sea-turtle is shown in (Fig. 7). This appearance is substantially the same as in *Chelydra*. A section through this ridged formation shows it to be formed of the foldings of the metaplexus in which the pia has become enormously thickened, until each fold is a solid mass of pia between the two layers of endyma. The endyma retains its one celled form. Fig. 17 shows a section of a single fold of adult plexus. Numerous blood vessels are found in this fold and among the fibrous pia layers connective tissue cells are numerous.

A sagittal section through the entire length of the metencephal near the meson (Fig. 16) shows the attachment of the metatela along the caudo-dorsal margin of the cerebellum. The endymal cells pass around the caudal portion of the metencephal and join the pia on the dorsal surface. The metaplexus is formed at once just caudad of the cerebellum, then the membrane is continued caudad in a direct course until near the caudal portion of the metacœle where it is folded and extends caudad of the closure of the metacœle as a distinct pocket. This pocket is formed of a very delicate membrane. In the embryo turtle (Fig. 19) I could detect no appreciable layer of pia crossing the meson but in the older turtles a thin layer was noticeable. In the large sea-turtle the same structure was found, but the membrane of the pocket was extremely thin. In the embryos of *Chelydra* the pocket was very small. This pocket seems to have considerable lateral extent. It is evident that it does not necessarily have the form shown in these sections, for being made of a very thin membrane it takes whatever form pressure and gravitation may dictate. That the form figured is most common results from the position in hardening and the presence of considerable quantity of fluid in the brain cavities. This pocket of extremely thin membrane is especially interesting as Wilder (92) has shown the presence of a metapore at this point in man and anthropoid apes, and Mrs. Gage (30) finds a similar opening in *Diemyctylus.* No metapore exists in the late embryo or adult turtle.

Endolymphatic Sacs.—The structure of these sacs differs little from that shown by Norris (56) and Mrs. Gage (30) in the Urodeles. The main body of these sacs lies along the skull dorsad of the metencephal (Fig. 19). They send branches along the caudal aspect of the gemina. These branches extend only along the caudal aspect of the mesencephal not reaching to the dorsal aspect as shown by Mrs. Gage in the brain of *Diemyctylus.* A tube leads from the main sacs cephalo-ventrad along the latero-ventral margin of the cerebellum to the ear cavity. The peculiar relation of this tube to the cerebellum in the embryo is shown in Fig. 18. These sacs do not unite across the meson, but in some portions as shown in Fig. 19 they are separated only by a blood vessel.

Blood Sinuses of Metencephal.—Lying dorsad of the tubes of the endolymphatic sacs, along the caudal portion of the cerebellum, is a small blood vessel. Following it caudad we soon find it widening, extending along the lateral wall of the skull cavity ectad and ventrad of the endolymphatic sacs, forming a broad sinus whose ental walls seem to be formed of the dura that splits into two laminæ for this purpose. Along the median dorsal wall of the skull is found another large blood vessel circular in transection which forms a partition between the endolymphatic sacs. Tracing the sinuses caudad we find them uniting across the dorsal median line forming a single vessel which extends caudad along the dorsal wall into the neck, where it grows smaller and disappears as a small blood vessel. The close relation of these sinuses and the endolymphatic sacs denotes a functional dependence of the latter upon a large blood supply.

EPENCEPHAL.

The Cerebellum.—The internal structure of the cerebellum is almost as simple as its outward form. It is entirely unconvoluted and has a curved outline in sagittal sections (Fig. 3).

A part of such a section is shown in Fig. 20. The internal structure is easily differentiated into three parts or layers. The ectal layer A is composed of neuroglia with a few scattered cells,—the typical structure of the barren cortical layer of the brain. As shown in the figure this layer has a slight fibrous appearance. This is probably due to remnants of epithelial structures. In young turtles there is a layer of small, deeply staining cells lying just entad of the pia. This layer was not found in the adults. These cells are probably the remnants of the embryonic cells from which the barren layer was developed. Entad of the barren layer is a layer of large Purkinje cells sending their processes ectad into the barren layer. These cells lie in a compact layer only one cell deep, they are oval in outline with large nuclei and deeply staining nucleoli (Fig. 20 B). The ental layer of the cerebellum is composed of densely packed, deeply staining cells lying in a thick stroma. These cells are quite similar to those lying scattered in the barren layer. This layer is bounded entad by the endyma.

At the base of the cerebellum on either side is found a small nidus—the dentate nidus of authors. These nidi lie at the level of the decussation of the 4th nerve and are closely enveloped by fiber tracts. They are composed of large cells of the oval type. Sagittal sections near the lateral margin of the cerebellum show, coming from that segment, a large fiber tract; this tract divides at the level of the base of the cerebellum and one part turns sharply cephalad into the mesencephal. The caudal part extends ventrad and subdividing sends one part to the region of the origin of the trigeminus, while a second branch curves caudad into the region of the origin of the acoustic nerve. In the cerebellum these tracts seem to be in close relation with the Purkinje cells.

MESENCEPHAL.

Structurally the mesencephal is limited cephalad by the post-commissure and the cephalic limit of the nidus of the 3d nerve. Its caudal limit in the dorsal wall is the decussation of the 4th nerve, while the ventral wall shows no clear point of demarcation. The mesocœle is, in its cephalic portion, a narrow, dorso-ventral slit widened slightly near its dorsal limit by the caudal continuation of the sulci of Monro. Passing caudad the cavity rapidly widens extending far laterad into each of the gemina forming the so-called optic ventricles. Farther caudad the cavity again narrows with its longer diameter dextro-sinistrad and passes, by the narrow aqueduct, into the metacœle. The colliculi of the mesencephal, first described and figured by Rabl-Rückhard in the alligator, are shown only slightly developed (Fig. 21).

Apparently three pairs of nerves originate in the mesencephal, but the cephalic pair, optic nerves, mainly terminate here. Originating in the retina the fibers of these nerves grow centrad, reaching the pregemina they expand covering the cephalic, lateral and dorsal portions of these lobes. These fibers have no direct cellular connections in the mesencephal but end in arborizations.

The oculo-motors arise from nidi lying in the cephalic part of the floor of the mesencephal on either side of the ventral slit of the mesocœle. Figure 21 shows a transection through the cephalic portion of these nidi. Here the nerve comes off in two main branches. The nidus lies near and ventrad of the main portion of the mesocœle, and dorso-mesad of the posterior longitudinal fasciculus. Farther caudad the nidus extends ventrad between the posterior longitudinal fasciculus and the ventral portion of the mesocœle, reaching nearly to the surface. No decussating fibers were found in this nerve. The trochlearis nerves arise from nidi caudad and slightly dorsad of those of the oculo-motors. These nidi are separated from those of the third nerve by a small space. The fibers arising from the nidi curve latero-caudo-dorsad around the lateral extensions of the mesocœle and meeting in the valvula form a conspicuous decussation (Figs. 22-23.)

Figure 22 shows a peculiar nidus—the interoptic nidus of Spitzka. This structure was first described by him in a paper upon the brain of *Iguana*. Subsequently he described the same in the turtles, *Nannemys guttata* and *Chelydra*. I have not been able to find a description of these structures by any other author. Even Herrick in his late papers on the reptilian brain seems entirely to overlook them. This is the more surprising as they are in *Chelydra* enormously large, being much larger than the nidi of the postgemina figured in all his works under the name of corpora posteriora. In outline this nidus is conical in form with the base caudad. This base projects caudad beyond the pregemina and forms externally the representatives of the "interoptic lobes" of Spitzka. These cones extend cephalad about two-thirds of the distance to the cephalic limit of the mesencephal. The structure of these nidi is similar to that of the nidi of the postgemina. Seen in transection (Fig. 22) they show as a compact oval mass sharply differentiated from the surrounding tissues by an almost open ring about them (Fig. 24). The ental surface especially is formed by a closely packed layer of small pyramidal cells with apexes toward the central part of the nidus, while the remaining surface of each nidus is composed of the same materials as the body. This body of the nidus consists of a dense stroma, probably glial in character, in which are imbedded scattered pyramidal cells. What the function of this large nidus may be I have not been able to ascertain. Lying laterad and slightly ventrad from the caudal portion of this nidus is another of very similar appearance and structure (Figs. 22-23). Its cells however are not distributed in rows along the surface of the nidus but are arranged in groups through the dense stroma and are more sharply pyramidal in outline. The general form of this nidus is irregularly conical, with the base caudad and the height of the cone about equal to the diameter of the base.

This nidus is the homolog of the postgeminum.

The Tectum Opticum. The structure of the roof of the optic lobes has been a very attractive subject for neurologists. Its structure of concentric layers and apparent simplicity combined with its function in the sense of vision, has brought many students to its study. Among those who have contributed to our knowledge of this interesting region are Osborn, Herrick, Nakagawa and Turner, of our own country, and especially Cajal and Van Gehuchten, of Europe. These latter authors by the use of the Golgi method have advanced our knowledge of this subject until it is now nearly complete. Van Gehuchten says that the Cajals have made a comparative study of the optic lobes in all classes of vertebrates but unfortunately this has not been published.

The various authors differ widely in their interpretation of the number of layers in the tectum opticum. Osborn describes eight in the frog, Nakagawa (57) probably following him, finds eight in Rana, Tropidonotus, Emys and Columba. Spitzka finds seven, but his ental layer includes the two ental of Nakagawa. I find these eight layers easy to recognize in *Chelydra.* In the bird, Turner (87) figures thirteen, Ramon y Cajal fifteen, Van Gehuchten (32) divides the tectum primarily into three but subdivides these layers again. He bases his division upon the probable function of the different parts. The ectal layer consists of the fibers of the optic nerve, these, as noted above, spread out over the tectum. The second layer includes all the space between this layer and the inner fibrous layer near the mesocœle (Fig. 25). The third is this inner fibrous layer. This division of the layers has a physiological clearness and is anatomically useful. The difference in the number of layers given by careful observers shows that a definite number is mostly a matter of personal preference. Figure 25 shows a portion of a frontal section of the tectum. In it the arrangement of the parts is figured. The three layers of Van Gehuchten are shown and also the eight layers of Nakagawa. No distinct boundary can be drawn between layers. Cajal divides the ectal layer of Van Gehuchten into seven and the middle layer into six. Reference to Figure 25 shows that the ectal layer of Van Gehuchten (A′) corresponds with the ectal layer of Nakagawa (A). This layer consists of retinal fibers and a few scattered cells. The middle layer of Van Gehuchten (B′) includes five of the layers of Nakagawa (B-F). The first four of these layers have the same essential structure and are differentiated only by the relative number of cells. These cells are oval, rather irregularly scattered through a stroma consisting mainly of neuroglia, but penetrated everywhere by fibers, that run generally parallel to the walls of the mesocœle. Near the ectal limit of layer C some cells are found that have their longer axes turned parallel to the ectal surface. Some authors have called this a separate layer for this reason, but as the fibers are slightly more numerous in this layer we doubt if there is any difference between these cells and those lying adjacent, excepting that of position, and that difference is probably the result of the pressure of the fibers. Layer D has numerous cells while layer E is mainly fibrous.

Layer F is the most clearly defined of the cellular layers and is probably the most important functionally. It consists of large pyramidal cells arranged in compact rows. These cells lie with their longer axes perpendicular to the walls of the mesocœle and their apexes directed peripherad. From the apex of each cell a process is sent off, these processes group themselves together, as shown in the figure, as they penetrate the fibrous layer E. They then extend in a straight line to the retinal fiber layer. According to Van Gehuchten all these processes end in the retinal layer, but with the method used I was not able to demonstrate this though the majority of them could be easily traced to these fibers. From the base of these cells other processes are given off, which form the greater part of the layer G. These are the axis cylinders. Layer H is composed of endymal cells.

In Figure 21 near the mesal line are shown some very large cells. These cells are found on either side of the meson throughout almost the entire length of the tectum. They constitute the so-called mesencephalic nidus of the trigemini. Some authors, among whom are Deiters and Golgi, refer them to the trochlearis. Golgi, in his paper on the origin of the trochlearis (34) maintains this view. He also figures these cells from the brain of the rabbit as being unipolar and says that they are absolutely so. His figures are taken from cells isolated by the maceration process, and he is forced to admit that neither by this nor by the silver method has he been able to trace the axis cylinder processes to their termination. Figure 26 shows two of these cells drawn with the camera lucida. These two cells were chosen as typical of this group in the turtle. As shown in the figure they are not in this form unipolar but bipolar and in some case I think even tripolar. The protoplasmic (?) process branches a short distance from the cell. This process is directed toward the periphery. The small process from the base is supposed to be the axis cylinder. The direction of the axis cylinder processes I was not able to ascertain. These cells are similar to those found in the brains of other turtles that I have examined.

Commissures of the Mesencephal. The post commissure forming the cephalic limit of the mesencephal is broad and strong, formed of fibers that pass laterad and slightly caudad into the ventral portion of the mesencephal. In the roof of the mesocœle is a narrow commissure extending from near the post commissure caudad for about two thirds of the length of the tectum (Fig. 6). This commissure is often called the commissure of the tectum, but Stieda first gave it the name of *Sylvian commissure* and this has been adopted in this paper. Near the cephalic limit of the mesencephal in its ventral floor is found another commissure. The fibers of this commissure penetrate between the roots of the oculo-motor nerve and through the bundle of the posterior longitudinal fasciculus. (Fig. 21). This commissure is of two parts, the more ventral part is the broadest and extends laterad and disappears, spreading diffusely in the peduncular region. To this commissure Stieda applies the name *inferior commissure*, but this name is open to the objection that it is more usually applied to the commissure of the infundibulum. Osborn calls it the superior infundibular commissure, but in the turtle it is not connected with any part of the infunbular wall. In this paper it is not named but is shown at x in figures 6, 7. In the vicinity of this commissure the posterior longitudinal fasciculi from a prominent decussation.

DIENCEPHAL.

The Roof of the Diencephal.[1]—In 1882 Rabl-Rückhard and

[1]Since this was written Sorensen's admirable resumè of the literature of the subject was received.

Ahlborn independently recognized the similarity which the structure of the "frontal organ" of Leydig presented to the structure of the lateral eyes and pronounced it to be an unpaired, degenerate organ of vision. Since that time the literature of this subject has grown to enormous proportions and at the present time there seems to be no cessation on the part of scientists, in their endeavors to discover the origin and development of this remarkable structure. The majority of investigators, including Spencer, de Graff, Strahl and Martin, Francotte and many others, unite in considering the pineal organ as the differentiated distal end of the epiphysis; while Béranéck, who first agreed with the above authors, now considers it an organ developed with, but independent of, the epiphysis, basing his claims upon the study of the embryo of *Anguis fragilis*. Francotte in his study of the embryo of the same animal interprets the appearances to show that the parietal eye is derived from the epiphysis. This position is vigorously maintained by de Klinckowström (51) who attributes Béranéck's failure to find the evidence of separation of the parietal eye to the lack of material at the correct stage of development. His work corroborates Francotte on *Anguis fragilis* and he figures like relations for *Iguana tubercculata*. Béranéck figures for the first time a nerve supplying this eye and considers it to spring from a cluster of cells cephalad of the origin of the epiphysis. Francotte was not able to trace the proximal connection of the nerve. De Klinckowström agrees with Béranéck in regard to the derivation of the nerve both in *Anguis* and in *Iguana*. Strahl and Martin in *Anguis* and Herrick (44) in *Phrynosoma* think the nerve springs from the supracommissure. Leydig believes the parietal organ develops independently of the epiphysis, denies its homology with a sensory organ aud consider the so-called nerve to be only a bit of connective or lymphatic tissue. But Leydig stands practically alone in his views. The homology of this organ is now generally accepted as being that of an organ of vision. But its origin, and the origin and relation of the nerve, are still open questions. Béranéck (10) in a reply to de Klinckowström makes the point, and we think justly, that in the case of the origin of the parietal eye from the epiphysis the origin of the nerve outside of the epiphysial stalk would vitiate the homology with the lateral eyes. If the homology is strictly true the stalk of the epiphysis would stand in the relation of the optic nerve. For the nerve to grow from the brain into the eye is a manner of development not found elsewhere in any sensory organ. In a recent article Locy (55) has shown in the early embryos of *Squalus acanthias*, the existence of three pairs of optic vesicles on the neural plate. The cephalic pair of these vesicles develops into the lateral eyes, the third pair disappears, while the middle pair passes into the diencephal, blends across the meson and develops from their dorsal edge the epiphysial outgrowth. This accords with the theory of homology with the lateral eyes, showing as it does the earliest origin of these organs to be exactly similar. Further investigation of this phase of development of the embryos of different forms will be awaited with interest, in the hope that it may aid in making clear the intricacies of this perplexing region and if possible bring into harmony the conflicting results of different observers.

No material being at hand for a study of the early development of the epiphysis, nothing has been attempted but to describe this organ and its relations in the late embryo and in the adult. The study of the embryos gave the most satisfactory results, both because of the manner of sectioning and the relative simplicity of the structure of the epiphysis and the surrounding organs. The pineal eye is not present in *Chelydra*. The epiphysis rises immediately caudad of the supracommissure and is projected cephalad in a curved course from its origin (Fig. 30). Its structure of columnar deeply staining endymal cells based upon a layer of connective tissue—pia, enables the observer to easily differentiate it from the surrounding structures. In form it is a slightly expanded sac, joined to the diencephal by a narrow stalk. This stalk becomes greatly lengthened and convoluted at its base in the adult. In the embryo of the advanced stage the cavity of the epiphysis is not connected with the diacœle (Fig. 30) but is closed by the thickening of the endymal cells just caudad of the supracommissure.

Whether this is true in the adult I am not able to say with confidence, though the evidence is in favor of it. Herrick (44) says that the cavities do communicate in turtles but his observations, I believe, are based upon the brain of *Cistudo.* In the adult the epiphysis is relatively longer than in the embryo but the width has not correspondingly increased. The enlarged distal portion has become lobulated by the pressure of the surrounding tissues. It is easily differentiated from the surrounding plexus, and careful study fails to reveal any bipartite structure or communication of its cavity with the cavity of the underlying structures.

That portion of the roof of the diacœle lying cephalad of the supracommissure is still a subject of dispute, both as to the number and character of its outgrowths and as to its cephalic limit. The most generally accepted interpretation is, that in this region two outgrowths are to be found, the most cephalic and earliest developed of which originates as an outgrowth of the prosencephal, while the other is formed from the growth of the diencephalic roof. The existence of two outgrowths in this region was first shown by Francotte (26) and to the cephalic one Selenka (74) applied the term paraphysis. Hoffman (49) figures and describes but one outgrowth which he says originates "between the prosencephal and diencephal." Kupffer (52) in *Acipenser* embryo figures two outgrowths separated by a wide velum transversum. He considers the velum to be the boundary between the brain segments. Herrick agrees with this view. Mrs. Gage shows the presence of two outgrowths in *Diemyctylus,* the cephalic of which she believes to mark the boundary between the brain segments. According to her view the velum belongs to the diencephal, and from the velum is developed the diaplexus which reaches, in the amphibian brain, an enormous development. Edinger (22) figures an ideal sagittal section of the reptile brain with a velum extending cephalad, forming the plexus of the prosencephal. The other parts have the usual relations. Sorensen (76) shows two evaginations in the duck embryo separated by the velum. To these he applies the terms pre- and post-paraphysis, following the nomenclature of Herrick.

The pre-paraphysis is the homologue of the paraphysis of most authors. Other authors that I have had access to consider the paraphysis as an outgrowth of the prosencephal and this interpretation has been accepted in the preparation of this paper, although this view involves in the adult brain, some rather anomalous relationships as will be pointed out hereafter.

The relation of these structures in *Chelydra* is in most respects similar to the generally accepted view. Immediately cephalad of the origin of the epiphysis the supracommissure arches across the diacœle connecting the habenæ. The pial and endymal layers of the epiphysis separate, the pia passing ectad of the commissure and the endymal layer entad. Cephalad these layers join again to form the thin membranous roof of the diacœle. This membrane is in every way similar to and in fact directly continuous with the plexuses of the diacœle, aula and paracœles. It is composed of a single layer of flattened, cuboidal, endymal cells with thin walls and lightly staining nuclei. Ectad of this is the exceedingly thin layer of pia formed of flat cells that take a yellowish red stain from the picric acid-fuchsin, enabling one to follow the intricate foldings of the membrane. This membrane grows dorsad of the brain tube almost completely surrounding the epiphysis in a closely folded mass. In the adult it is continued cephalad of the tip of the epiphysis and forms the supraplexus. I believe this sac to be the homologue of the Zirbelpolster of German authors and of the post-paraphysis of Herrick. To call this "the second vesicle of the epiphysis," as is done by some authors, is very misleading as it has absolutely no connection with the epiphysis proper. The general form of this structure as shown in sagittal sections (Fig. 30) is that of an expanded, wide-mouthed sac opening into the diacœle. Frontal sections (Figs. 27-29) also show this opening to be quite wide. The cephalic wall of this sac, as shown in figures 27-29, consists of a single layer of this membrane stretching across between the solid walls of the diencephal, and slightly folded in its course. Both sagittal and frontal sections of this region show cephalad of this sac a second sac—the paraphysis. Its general form is conical or pear-shaped with the base directed dorsad, the wide dorsal end becomes folded upon itself forming, especially in the adult, a great number of lobes or diverticles. Its structure easily differentiates it from the surrounding tissues. Its ental or endymal layer, is formed of cubical, thick-walled cells with large, deeply staining nuclei. The ectal or pial layer is thicker than the same in the dorsal sac and takes a deeper stain with the picric acid-fuchsin. The relation of the paraphysis to the dorsal sac is clearly shown in both sagittal sections (Fig. 30) and frontal sections (Figs. 27-29). Tracing the structures ventrad by frontal sections we find (Fig. 27) that the narrow neck of the paraphysis lies just cephalad of the transverse wall of the dorsal sac. A section a short distance ventrad (Fig. 28) shows the union of the neck of the paraphysis with the membrane of the dorsal sac and the opening of the former into the diacœle. Continuing ventrad we find the membrane stretching across between the walls of the diacœle with only a slight folding. A frontal section at the portas shows the formation of the various plexuses from this membrane. The same essential relations are shown in a sagittal section (Fig. 30) near the meson. The dipping down of the dorsal sac to join the mouth of the paraphysis forms the velum and is to be considered the morphological limit of the diencephal. No diaplexus is developed from the velum. The paraphysis opens into the diacœle and we have part of that cavity roofed by the prosencephal. These same relations are shown by Herrick (44) to exist in *Cistudo.*

While we find the three outgrowths of the diencephalic roof differentiated by their histological structure as well as form, it is to be remembered that, as the cephalic continuation of the paraphysis passes into the plexuses it becomes histologically identical with the membrane of the dorsal sac. This would seem to point to the fact that the two outgrowths were originally of similar histological structure and that they were secondarily differentiated by some difference of function. The paraphysis is almost completely surrounded by a large blood sinus and has the same relations to the blood supply of this portion of the brain that the endolymphatic sacs bear to the supply in the region of the metaplexus. The indications point to the paraphysis being directly concerned in the lymph supply of the brain.

The relation of these structures in the large sea turtle, *Chelone midas,* is very similar though it undergoes some modifications. The whole dorsal outgrowth (Fig. 7) including epiphysis, dorsal sac and paraphysis, is relatively enormous in size. It grows almost perpendicularly to the longitudinal brain axis, not curving forward as it does in *Chelydra.* The epiphysis is very long and slender with an exceedingly tortuous narrow stalk and is much folded upon itself but has little widening at the distal end. The dorsal sac is very spacious. Its lateral and caudal walls are formed of the single unconvoluted membrane. Unlike the same membrane in *Chelydra* it is not folded about the epiphysis except at its distal end. Around the distal end and cephalo-dorsad of it the membrane is closely convoluted forming what appears to the naked eye a thick, solid roof to the dorsal outgrowth. The velum is relatively slightly developed hanging down from the cephalic portion of the dorsal sac but not reaching to the brain. The paraphysis is very well marked and is greatly infolded and lobulated. Its cephalic wall drops down between the diencephal and hemispheres and from it are formed the large plexuses of the diencephal and prosencephal.

Structure of the Thalami.—In figures 6, 7 the supracommissure is shown as it arches over the diacœle. If we trace this commissure laterad we find that it soon divides into two portions; the caudal branch curves sharply and descends almost directly ventrad into the body of the thalamus (Fig. 31). The cephalic branch passes laterad and slightly cephalad to the lateral margin of the diencephal and then is continued cephalo-ventrad ectad of the optic tracts passing ventrad of the porta and entering the cerebrum immediately laterad of the peduncular tract where it turns sharply and is distributed to the ventro-occipital portion of the cerebrum. Osborn has found similar relations in *Cryptobranchus.* Whether the caudal bundle of the supracommissure is the homologue of Herrick's "commissura habenaria" I am not able to say. I am certain however that its fibers do not extend cephalad in their course until they have at least passed for some distance into the substance of the thalamus (Fig. 31). On the contrary they pass slightly caudad and give no evidence of extending into the cerebrum as he suggests.

The remaining structures of the diencephal have been carefully described by Herrick (43), and the description here given only confirms his observations, differing from them only in a few minor points. Cephalad and mesad of the supracommissural tracts is found the nidus of the habena consisting of thickly clustered cells. The caudal portion of this nidus is shown in Fig. 31. Cephalad and slightly ventrad of it lies another nidus, in which the cells are less closely packed. This is Meynert's nidus and from it the fibers of Meynert's bundle originate and extending caudo-ventrad end in the floor of the cephalic portion of the mesocœle in close relation with the oculo-motor nidus (Fig. 36). This fiber bundle in the turtle is diffuse and does not show so plainly as the corresponding tract in the Amphibia. Directly ventrad of the nidus of the habena lies a large dense nidus, nearly globular in form, that is the most conspicuous object in the sections of this region (Fig. 31). Its structure consists of a very dense ground work or stroma that is pierced by a great number of blood vessels. In this stroma are imbedded scattered cells. To this has been given the name of nidus centralis. From its ventro-mesal portion fibers are given off that extend ventro-cephalad (Fig. 31). Laterad of the nidus are found the small geniculata into which optic fibers penetrate. In the turtles the geniculata are not well developed or differeniated from the surrounding tissues. Fig. 31 shows a section of the extreme caudal part of this structure. Ventrad of the nidus centralis lying near the meson is another nidus that consists of cells thickly clustered together. This is, I believe, the "nidus sub-thalamicus" of Herrick. From its lateral margin fibers are given off that join with the bundle from the nidus centralis (Fig. 31). Caudad of these structures is another nidus lying ventrad of Meynert's bundle (Fig. 36) to which the name ruber was given, following the interpretation of Herrick.

Large cells extend from the region of the nidus subthalamicus ventrad near the meson into the infundibulum. These cells are of the true nervous type. The remaining regions show the usual structure of the brain substance. The peduncular tracts are shown lying laterad near the optic tracts (Fig. 21).

The optic tracts lie on either side of the diencephal with the main portion of the fibers extending into the tectum of the pregemina. A few of its fibers penetrate the walls of the diencephal and seem to end in the geniculata and the substance of the brain immediately laterad and dorsad of those structures in the region probably corresponding to the pulvinar of man.

The Infundibulum.—The general form of the infundibulum is shown in Fig. 3. The base of this structure is thick and contains layers of true nerve cells lying near the ental walls, but its apex becomes thin walled and at the extremity is expanded into a lobulated sac, the homolog of the sacculus of other forms. The ventral wall of the distal portion is thin, consisting of endyma and a very thin layer of neuroglia through which the processes of the endymal cells extend. This thin portion lies upon the hypophysis while the lobulated portion overlaps the latter structure on its lateral and caudal portions. The relation of these structures in the embryo is shown in figure 32. In this stage of development the distal portion of the infundibulum is relatively smaller than in the adult. The dorsal wall of the infundibulum is thicker and has a more truly nervous structure, except at the very distal portion. Fibers crossing the meson ventro-caudad of the chiasma and forming the inferior commissure connect the two sides of the base of the infundibulum.

The Hypophysis.—Fig. 32 shows the relation of this structure to the infundibulum and the floor of the brain cavity. I can find only slight evidence of any division into parts as suggested by Gaupp (31). As this was in the advanced embryo it may be possible that younger embryos would reveal the tripartite structure which he describes in other reptiles. In internal structure the hypophysis is composed of glandular epithelium so closely folded upon itself that it is in the advanced embryo almost without any cavities. The pia separates it from the infundibulum and also sends wrapping membranes around its various coils. I could find no evidence of penetration of its folds by the dura.

The Sulcus of Monro.—Reichert (69) first described this sulcus in the human brain, where it extends from the porta to the mesencephal and is called aulix by Wilder. Its morphological importance is now recognized as it is the accepted boundary between the dorsal and ventral zones of His. In the turtle it is clearly shown extending from the porta ventrad of the medicomissure to the cephalic part of the mesocœle where it disappears (Figs 6 and 7.) I have not been able to detect sulci cephalad of the metencephal that have any apparent morphological significance. Sulci similar to those elsewhere described as secondary are numerous in many portions of the brain.

The Prosoplexus.—In the discussion of the roof of the diencephal attention was called to the fact that the plexus in the diacœle and about the region of the portas was derived from the prosencephalic roof cephalad of the paraphysis. To this plexus as a whole the term prosoplexus has been given. It is subdivided into different parts according to the region in which the parts occur and the usual names have been given to each. The plexuses of the Amphibia have been worked out very completely by Mrs. Gage (30) and also by Mr. P. A. Fish in a paper now preparing. These authors agree that a large plexus is developed immediately caudad of the paraphysis from the velum-transversum of authors. This plexus hangs down into the diacœle and extends caudad into the mesocœle. To this plexus they apply the name of diaplexus. Cephalad of the paraphysis another plexus (prosoplexus) is formed whose branches form the various plexuses of the region of the portas and paracœles. In the turtle only this latter plexus is represented, no plexus being developed from the velum. Cephalad of the paraphysis the plexus drops down into the aula forming the auli- and paraplexuses. From this region it extends into the paracœle to a distance varying in different individuals, sometimes reaching to the rhinocœles. From the aula a part drops down into the cephalic portion of the diacœle, reaching in the adult specimens far into the infundibulum. As this plexus, though in the diacœle, is not the homologue of the diaplexus of Amphibia I propose for it the name of *infundibular plexus*. In adult specimens the folds of the plexuses were found united by the thickening of the pia layers as is shown in Fig. 17 for the metaplexus.

Crista.—Wilder (91) first called attention to this structure in the brain of the cat where it projects into the aula as a semioval elevation of a peculiar pellucid, gelatinous appearance in the fresh brain. He has also observed the same in the brain of the sheep and the human fetus. He suggests the possibility of its marking the limit of the primitive terma. No one else seems to have obsrved it as such until Mrs. Gage announced its presence in the *Diemyctylus* and *Amia*. In these animals it is small but well marked. In *Desmognathus*, Fish has found it to be simply membranous. In the turtle it is present and shows an interesting variation in forms that are in general structure very similar. Its location is on the meson projecting into the aula immediately dorsad of the callosum (Figs. 6 and 33). In *Chelydra* it consists simply of an invagination of the membrane as it spans across from one hemisphere to the other. This condition was found in both embryos and adults. In *Chrysemys* exactly the same formation was found. In *Chelone* it presents a very important modification. The whole structure is well developed and appears to the naked eye as a pyriform mass with the stem projecting dorsad (Fig. 33). This structure is best studied in a series of frontal sections. Figure 34 shows a section through the stem of this pear shaped body. Here the structure consists mainly of endyma and pia. The endymal cells are peculiarly modified, being very narrow and having processes that project toward the pia and are so closely interwoven with the pial processes that they seem continuous and any clear demarcation between the two membranes is impossible. At the sides of the crista where they join the hemispheres the walls are made up of endyma and a layer of neuroglia. Nowhere does the pia seem to lie close to the walls of the structure except at its extremity where it is attached. A blood vessel is found in the pia near its point of attachment. Following the sections ventrad we find that the blood vessel divides as the crista enlarges and the pia also splits giving it a forked appearance in frontal sections (Fig. 35). As this branching of the vessel and splitting of the pia occurs, the central portion of the wall between the two laminæ of the pia begins to thicken and as we proceed ventrad we find it projecting into the interior of the structure as a ridge cone shaped in transection. This ridge is of neuroglia and its limiting endyma has the normal appearance of that membrane, while at either side, opposite the attachment of the pia the cells have the long shape with processes toward the pia (Fig. 35). The base of the walls as shown in the figure is of the normal neuroglia structure. Herrick (44, plate XV, Fig. 5) figures a structure in this region in the brain of Menopoma and applies to it the term callosum. Whether it contains fibers or not I could ascertain.

The presence of this structure in so many forms of vertebrates argues some morphological importance for it. Work is now in progress in the laboratories of Cornell University which it is hoped will be able to throw the light of comparative study upon this small but persistent structure.

Callosum.—Since the announcement by Osborn of the presence of the callosum and a probable fornix in Reptilia, the subject has been carefully investigated by different workers and the almost unanimous opinion is that both of these structures are present. Of recent writers Meyer alone seems to doubt the homology. It is generally accepted, that the commissural fibers lying in the terma ventrad of the porta and connecting the mesal portions of the cerebral cortex, represent the callosum of the higher vertebrates. The relation of the callosum and precommissure varies considerably in Reptilia. In *Chelydra*, as pointed out by Herrick (44), these bundles are brought into juxtaposition and cross the meson as a single bundle. This bundle extends laterad a short distance and then divides, the ventral portion extending latero-cephalad as the true precommissure (Fig. 36). With the methods used I was unable to trace the fibers of the precommissure to their distribution. The dorsal bundle extends cephalo-dorsad in a curved course. When about the level of the dorsal margin it divides, one large branch turns sharply caudad, passes near the dorsal margin of the porta and is distributed to the caudo-mesal cortex of the cerebrum. I consider this to be the homologue of the commissura cornu ammonis of Osborn and in all probability it is a part of the callosum. Its distribution is as shown by Osborn in *Emys Europea* (59, Fig. 18). The cephalic branch of the commissure spreads out over the mesal cortex, and is the homologue of the callosum of Herrick (Fig. 36.)

Similar relations exist in the brain of *Chelone* and *Chrysemys*. In the latter the common bundle projects more sharply into the aula at the meson and is almost freed from the terma. In *Chelone* the common bundle was placed farther ventrad than in other forms observed (Fig. 7.) The presence of descending fornix tracts was not proven although in *Chelydra* there is evidence of their presence. The prosencephal of reptiles has been so thoroughly studied of late by Edinger, Herrick, Meyer and others, that I have made no attempt at the almost hopeless task of adding to the knowledge of that interesting region.

SUMMARY.

1. The brain of *Chelydra* is probably the most simple of the Reptilia. While it approximates the Amphibia in external simplicity, internally it contains representatives of nearly every structure of the higher types of brains.

2. The sulci of the metencephal are formed by the apposition of cylindrical fiber columns and owe their depth and location to the position of the columns.

3. The metacœle is continued caudad of its union with the myelocœle and dorsal furrow and is demarcated from them with unusual clearness.

4. A distinct pocket exists in the metatela in the region of the metapore of some other animals. This pocket is extremely thin-walled in the late embryo and the possibility exists that a

metapore is to be found in the early embryo which closes near the end of fetal life.

5. The inter-optic lobes are highly developed in turtles. In *Chelydra* they show externally as small lobes caudad of the base of the pregemina, but in other forms, as pointed out by Spitzka, they exist only as large nidi.

6. In the roof of the diencephal of the turtle three evaginations exist. The "velum transversum" is only slightly developed and from it no plexus is formed as is the case in Amphibia.

7. The plexuses of the regions of the portæ and aula are all prosencephalic in origin.

8. The crista is present in all forms examined. In *Chelone midas* only did it possess a true nervous structure. Its morphological value was not ascertained.

The foregoing paper was prepared in the laboratories of the Anatomical Department of the Cornell University. To the kind assistance of the members of that Department, and especially to the discussions in the Neurological Conferences, I owe a great part of whatever of value the paper contains.

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EXPLANATION OF PLATES.

ABBREVIATIONS.

a.—aula.
ap.—auliplexus.
b. sn.—blood sinus.
b. v.—blood vessel.
cal.—callosum.
cb.—cerebrum.
cbl.—cerebellum.
ch.—chiasma.
crs.—crista.
d.—dura.
dc.—diacœle.
dec.—decussation.
dor. cn.—dorsal cornu.
" *col.*— " column.
" *f.*— " fissure.
" *out.*— " outgrowth.
" *sac.*— " sac.
dp.—diaplexus.
els.—endolymphatic sac.
el. t.— " tube.
end.—endyma.
Ep.—Epencephal.
epi.—epiphysis.
hph.—hypophysis.
incs.—inferior commissure.
inop.—interoptic lobes.
ino. ni.—interoptic nidus.
inf.—infundibulum.
l.—lophius.
lat. col.—lateral column.
lat. sl.—lateral sulcus.
ni.—nidus.
ni. ct.—nidus centralis.
ni. hb.—nidus habenæ.
ni. rp.—nidus of raphe.
ni. sth.—nidus subthalamicus.
mcs.—medi-commissure.
Mes.—Mesencephal.
Met.—Metencephal.
msc.—mesocœle.
mtc.—metacœle.
mtpx.—metaplexus.
mttl.—metatela.
my.—myel.
myc.—myelocœle.
My. ni.—Meynert's nidus.
My. bl.—Meynert's bundle.
ol.—olfactory lobes.
op. rc.—optic recess.
op. tr.—optic tract.
p.—porta.
par.—paraphysis.
pc.—paracœle.
pcs.—post-commissure.
pdcl.—peduncle.
pi.—pia.
p. l. fas.—posterior longitudinal fasciculus.
pm. sl.—paramesal sulcus.
pp.—paraplexus.
prcs.—pre-commissure.
prg.—pre-gemina.
Pros.—Prosencephal.
psg.—post-gemina.
psg. ni.—post-geminal nidus.
rb.—ruber.
Rhin.—Rhinencephal.
rp.—raphe.
rt. ar.—reticular area.
scs.—supra-commissure.
sc. sl.—secondary sulcus.
sl. Mn.—sulcus of Monro.
spx.—superplexus.
st.—striatum.
Sycs.—Sylvian commissure.
t.—terma.
tr. cbl.—tracts of cerebellum.
v.—velum.
vn. cn.—ventral cornu.
vn. col.—ventral column.

DESCRIPTION OF FIGURES.

PLATES II, III AND IV.

Fig. 1. Dorsal view of the brain of an adult *Chelydra*, x 3, drawn with pia only adhering. Shows the segmentation of the brain, its length compared with the transverse diameter, the origin of the nerves and the slight development of the post-gemina and "inter-optic lobes."

Fig. 2. Ventral view of same. Shows the lobed condition of the cerebrum and the general narrowness of the ventral regions when compared with the dorsal portion of the brain. Also ectal nerve origins.

Fig. 3. Lateral view of same. Drawn to show the segmentation of the brain which is revealed most plainly from this view. In these three figures the metatela is not shown.

Fig. 4. Dorsal view of the brain of an embryo *Chelydra* nearly ready for hatching, x 4. Shows a more compact structure but does not exhibit the great amount of flexure that really exists in the brain at this time.

Fig. 5. Dorsal view of the epencephal and metencephal. Showing the metatela in its natural position. Enlarged the same as figures 1 and 3.

Fig. 6. A mesal view of the diencephal and mesencephal of *Chelydra* to show the relations in those very complex regions. In this figure no membranous portions are shown. It shows the position of the commissures, the relations of the different cavities, main sulci etc.

Fig. 7. A mesal view of the entire brain of the great sea turtle, x 2. Shows in addition to the features shown by figure six membranous portions of the brain roof, especially the metatela and the three parts of the diencephalic dorsal outgrowth. The larger relative size of the cerebrum and cerebellum are to be noticed.

Figs. 8–15. A series of transections of the metencephal of an adult *Chelydra*, arranged with the caudal sections first.

Fig. 8. Shows a transection of the metencephal at its caudal limit, the caudal continuation of the metacœle, as three pockets, the outlines of the cinerea and the general distribution of the fibrous columns.

Fig. 9. Showing blending of pockets of metacœle and the union with dorsal furrow and myelocœle, also a slight change in the position of the dorsal column.

Fig. 10. Shows widening of the metacœle, a further change of form of the dorsal column and the projection of the dorso-lateral portion of the general parietes, also the beginning of the reticular area.

Fig. 11. Carries these changes still farther. In addition is shown the central lophius and several secondary sulci in the floor of the metacœle, while the ventral bundle becomes plainly the posterior longitudinal fasciculus.

Fig. 12. In this the widening of the metacœle is very great with consequent changes in position of fibrous columns; the reticular area is greatly increased, while the dorsal cornu is much reduced. A large nucleus is shown in the raphe.

Fig. 13. Here the dorsal column is partly divided forming a sulcus at *a*. The lateral sulcus is shallow while the paramesal sulcus is deepened by the raising of the posterior longitudinal fasciculus into the metacœle.

Fig. 14. Sections of the caudal portions of the 8th nerve. The dorsal column has become more compact while the region of the lateral column has become massive. The lateral sulcus is almost obliterated while the paramesal sulcus deepened. The mesal furrow has deepened and the mesal lophius is reduced to a very small ridge.

Fig. 15. A section through the origin of the 5th nerve. Shows a reduction in the region of the dorsal column, but an increase in the region of the lateral column with a projection of that region where the nerve enters, also two nidi are shown at *a* and *b*.

Fig. 16. A sagittal section through the brain of a small turtle showing the formation of the metaplexus and the caudal pocket of the metatela.

Fig. 17. A section through a single fold of the metatela of an adult turtle. Shows the blending of the two layers of the pia and numerous blood vessels piercing it. In this the endyma is indicated by a heavy line while the blood vessels are seen as vacant spaces.

Fig. 18. A transection through the caudal part of the cerebellum of an embryo. Shows the formaton of the metaplexus and the relation of the tubes of the endolymphatic sac to the cerebellum.

Fig. 19. A transection through the region of the metencephal of an embryo, caudad of the cerebellum. Shows the metatela and and the relation of the endolymphatic sacs and blood sinuses.

Fig. 20. Part of a sagittal section through the cerebellum of an adult turtle, to show the general histological structure.

Fig. 21. A transection of the mesencephal in the region of the origin of oculo-motor nerve. Details not filled in. Shows origin of oculo-motor nerve, commissures of the mesencephal, inter-optic nidus and main nerve tracts.

Fig. 22. A similar section at the origin of the trochlearis, showing also the inter-optic and post-geminal nidi.

Fig. 23. Section through the decussation of the trochlearis and showing the post-geminal nidi.

Fig. 24. A section of the inter-optic nidus to show the peculiar open space about it.

Fig. 25. Part of a section of the tectum showing its structure. The layers are indicated as shown by Nakagawa and Van Gehuchten.

Fig. 26. Two cells from the mesencephalic nidus of the trigeminus.

Fig. 27. Part of a frontal section of an embryo brain at the level of the supracommissure. Shows the relations of the various parts of the diacœlian roof.

Fig. 28. Section of the same farther ventrad. Shows relation of the dorsal sac to the diencephal and opening of the paraphysis into the diacœle.

Fig. 29. Section of the same farther ventrad. Shows the membrane of dorsal sac stretching across between the diacœlian walls. It still contains a few cells from the paraphysis.

Fig. 30. A sagittal section near the meson through the brain of an embryo. Shows the relations of the structures in the roof of the diacœle from the mesal aspect. It also shows the formation of the plexus of the aula from the membrane cephalad of the paraphysis.

Fig. 31. Transection of the diencephal through the posterior part of the diencephal, slightly diagramatic. Shows the relations of the caudal division of the supracommissure and the various nidi of that region.

Fig. 32. Sagittal section through the hypophysis of an embryo *Chelydra.* Shows the structure of the hypophysis, and its relations to the infundibulum, pia and dura.

Fig. 33. View of the regions of the aula and portæ from the caudal aspect in the brain of *Chelone midas.* Made by transecting the brain through the caudal part of the portæ. Shows the position of the crista and the callosum.

Fig. 34. Frontal section through the stem of the crista. Shows its structure and relations to the pia and hemi-cerebrums.

Fig. 35. Frontal section through the main body of the crista. Shows its general structure, the peculiar splitting of the pia with the intrusion of the nervous substance between the laminæ of the pia.

Fig. 36. Diagram of the relations of some of the principal commissural and decussating tracts and the large nidi of the brain, seen from the mesal aspect as if the brain were transparent. Only position of tracts is shown, relative size being disregarded.

STUDIES FROM THE NEUROLOGICAL LABORATORY OF DENISON UNIVERSITY.

X. The Nose and Jacobson's Organ with Especial Reference to Amphibia.

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I. Introductory.

It is the purpose of this introduction, first that we may become well-orienated ourselves in undertaking to carry on our original investigation; and further to assist those who may not be so familiar with this particular subject in taking in the full significance of any new facts which have recently been established. It is designed also to group together a few significant generalizations which seem important in this connection. If this sketch appears imperfect, it must be remembered that other points are elaborated below.

The olfactory organ as one of the five principal organs of sense takes an important place in the studies of the Morphologist. Offering, as it appears to, at first sight, greater simplicity of structure than either the optic or auditory apparatus, it has seemed to promise an easier field for investigation as well as a greater variety of results. But upon deeper and closer study the true complexity of the relations, both morphological and histological, is brought to light, and the more far-reaching the study, the greater the emphasis which is laid upon the fact. The only means therefore by which we can soon acquaint ourselves with the main facts is by viewing the whole question successively from different standpoints. The great diversity in the configuration of the peripheral organs allows great range for comparison, while the circuitous internal connections, though but imperfectly made out, have not prevented the publication of certain psycho-genetic conclusions. But although there are many questions which arise in this study which seem as far as ever from an adequate answer, yet there are other questions which seem to require but persistent and thorough investigation to yield fruitful results. Perhaps this is not more true of the olfactory organs than of others, but certainly there is evidence of a simpler functioning than is the case in the eye and ear at least, whether the organs themselves are correspondingly more simple in structure or not.

Smell is one of the earliest senses phylogenetically. Hints of such a sense are found in the function of the processes and antennæ found in many invertebrates, (*star-fish, insects, etc.*) *Ants* communicate by means of their antennæ, and the fact that recognition is prevented by immersion in water, along with other experiments, suggests that such recognition is largely at least due to olfaction. An ant immersed as above described is immediately set upon and destroyed by its fellows, comrades in the same colony, after a short examination of the victim by means of those infallible sense-bearing feelers. The explanation is that the peculiar odor characteristic of each member of a given colony is lost by this submersion of the ant. The supra-œsophagal ganglia found in some types are supposed to be not a "brain" as often described but a mass of sensory organs among which is a more or less highly differentiated proton of an olfactory apparatus. This reference, however fanciful and perhaps unreliable, may assist in homologizing invertebrates in this respect with higher forms.

1. Perhaps the most probable theory as to the *origin of the primitive olfactory epithelium sacs* is that which postulates their origin from the lateral line system. This theory is supported by such authors as Beard, who is very explicit on this point. He says: "The nose and ear are in the same category of sense-organs as those of the lateral line (the branchial sense-organs), a system of sense-organs which vertebrates have inherited from their annelidan ancestors. The power to evolve new sense-organs from indifferent foundations must be absolutely refused

to vertebrates. They can form new sense-organs only by a further differentiation of the segmentally arranged sense organs which already exist and which have been inherited from the Annelida, their ancestors." That is, he maintains that the nose and ear are comparable in origin, not being modified gill-clefts as formerly supposed, but developed from these simple paired pits which (as in the fish) are found scattered about the head and arranged in a line along the lateral aspect of these lower types. Like the lens and labyrinth of the ear, they are formed from the external epithelium; unlike them them are never closed up. The nasal epithelium depression which so much resembles in early development the corresponding optic and auditory depressions, is developed a little later in the history of the individual (that is, in the development, or ontogeny) and like them, from the outer germ-layer. This *nasal area* lies on either side of the frontal process in the embryo. Early in the process of the differentiation the edges or rims of these depressions rise into folds or ridges. As these thicken there is a corresponding proliferation of neural cells from the brain-tube which come into connection with the cells of these thickened walls. This is what may be called the primitive olfactory ganglionic foundation. This evagination of the cerebral vesicle is undoubtedly the fundament of the olfactory lobe, while the fibrillæ which terminate in this thickened epithelium are later carried back to form the olfactory bulb and nerve bundles. Thus the nose is all developed, really, by the growth and differentiation of one small piece of sensory epithelium.

Embryonic development.—The olfactory is connected with and associated with the pituitary in the embryonic development, and as recently shown, they are really situated upon the dorsal surface. The olfactory nerve is supposed by some to be the supra-branchial branch which has every other element suppressed. The olfactory nerve is formed from the anterior cerebral as a secondary vesicle on its under surface. Professor Beard says, "In brief the olfactory nerve, or better, the olfactory ganglionic foundation, is derived from two sources, the lateral ganglion and the neural ganlion, as is true for all true cranial segmental ganglia."

Naturally, next, would follow a rapid survey of the progressive differences in general configuration of the peripheral organs, but as this will necessarily be referred to under other topics we will not lengthen the review by introducing a full discussion here.

2. *Evolution of the external and internal nares.*—In lower vertebrates the olfactory opening is single. In *fishes* the olfactory sac divides and each comes to have two openings but neither is within the mouth. It would appear that in higher vertebrates the mouth becomes more extensive and envelopes the caudal opening of the nasal sac, producing the internal nares.

Ganoids and Teleosts have two external openings, anterior and posterior, through which the water passes.

In *Amphibians* it is said that the posterior nares are formed in a different manner. The groove closes completely behind and a new perforation is formed from the blind end of the original nasal groove. Balfour ("Comparative Embryology," from whom this is condensed) thinks this is a secondary process.

Both external and internal orifices are situated far forward near the edge of the mouth in *Dipnoi* and the *amphibian* stage.

In Dipnoi, says Le Conte, we have for the first time *nostrils.* These fishes completely combine gill-breathing with lung-breathing. The steps from these to the lowest amphibian reptiles is so small, that some have classed the *lepidosiren* among amphibians instead of fishes.

In *lizards* the method of formation of the internal nares is somewhat different. A groove connecting the nasal sac with the roof of the mouth is formed, but it forms on the inner aspect a great lateral diverticle clothed with a continuation of Schneider's epithelium, and forms the fundament of Jacobson's organ. Subsequently the groove is closed in and Jacobson's organ separates from the nasal passage and acquires a new opening into the mouth at the front end of a groove running back to the posterior nares.

In *birds* the nasal sac is extended to form a groove. The hinder part becomes enclosed in the mouth and closes except at the posterior where it remains open, forming the posterior (or internal) nares.

3. An interesting field for further investigation is the *evolution of the respiratory regions* of the nose. The nose is one of the organs which serve a double purpose. It is not only the seat of the sense of smell, but was evidently intended to be also the principal organ through which an animal breathes. Its more or less circuitous passages, warm and moist, protect the lungs by taking the chill from the inspired air and arresting irritating dust. The cavity of the nostril in many types is extended by means of certain so-called turbinated bones, covered by the extremely sensitive olfactory membrane. This cavity is further separated into two parts, the respiratory passages of the nose, and the true olfactory centers. The latter are usually situated farther entad, so that in general it is not true that the entire olfactory epithelium is concerned in the act of smelling. In man, for example, the terminal nerve cells which alone take cognizance of odors are situated in the upper third of the nasal chambers out of the line of the ordinary inhalation. For this reason we do not usually notice odors except when we sniff—draw the air into the upper part of the nostrils and hold it there a moment—when we may become aware of even the faintest scent.

The fact that certain *Amphibia* during their aquatic life do not possess ciliated epithelium but when entering upon their terrestrial life acquire it, seems to indicate that the possession of such epithelium bears some relation to the necessary circulation of the air through the nasal passages during the land-life of these types. There certainly is some significance in the fact that as a class aquatic animals are not supplied, while as a class land animals are supplied with this ciliated olfactory epithelium. Some have suggested that the cilia serve to renew the medium bearing the odoriferous particles, but this perhaps would conflict with the fact that in the olfactory region, in higher types—i. e. the region in which the terminal filaments from the olfactory bulb are distributed—the epithelium cells are columnar and non-ciliated (Ref. Handbk Med. Sciences, Lit. No. 28.) while in the respiratory portion of the nasal cavity the epithelium is columnar and ciliated.

The Dipnoi are the lowest types in which the nasal cavity begins to differentiate for the secondary function of a respiratory passage, from this stage onward the olfactory sac being in communication with the mouth.

4. *Psycho-genetic conclusions regarding the sense of smell.* This is an apparently unworked field. Such questions as the relation of the nasal apparatus to the habits of the animal; the psychogenesis of smell, etc., have but lately received any attention deserving notice.

Edinger's psychogenetic conclusions.—Although the olfactory sac is developed by invagination of the ectoderm, and hence the olfactory organ is developed later than the numerous tactile organs scattered over the whole epidermis, yet the sense of smell seems to be developed before the sense of touch. We must not regard those reflexes which are seen in the motions of the amœba and other low forms as indicating the possession of any true sense of touch, but only a susceptibility to stimulus, that is, mere irritability. Thus we see that although the organs of touch precede in development the organs of smell, yet because the latter form their central connection first, the sense corresponding is the first to be developed. That is, we may say that touch and smell existed, and touch existed before smell, but the sense of smell was the first to become conscious. (Properly speaking of course, the sense of smell or touch is not rightly called a sense until it becomes conscious.) Now the psychical processes which pertain to the sense of smell have been referred to (i. e. have their center in) the hippocampus. And if it is true as seems almost certain that the Ammon's horn which is the homologue of the hippocampus in lower types, is the first cortical center to develop, then it would seem to follow that the first psychical function to develop, corresponding to this most primitive establishment of cerebral connections, is the sense of smell. As Edinger says: "We are today justified in assuming that the cortex is the bearer of the higher psychical functions. If then it is true that the olfactory tract connects with the higher centers first in phylogenetic development, then it follows that the earliest cortical activity is associated with the perceptions of smell." What the ultimate significance of the early development of the olfactory sense may be, is yet to be determined.

With regard to the *delicacy of the sense of smell* even in the higher types where it is not so fine a sense, it has been shown by experiment that $\frac{1}{400,000,000}$ part of a milligram of polycarpine, or $\frac{1}{300,000}$ part of a milligram of bromine, in one square centimeter of air is perceptible. Olfactory sensations are probably received from material emanations from the odoriferous substance, the emanations being absorbed by the fluid in which the end-cells are imbathed. This moisture is so essential to the proper action of these cells that its absence, as in certain stages of a cold and in certain diseases, may for the time quite destroy the sense of smell. For the same reason odors are less readily perceived in an uncommonly dry atmosphere. This blunting of the sense is brought about also by certain occupations which necessitate working in a dusty atmosphere.

The nerves of smell may become the seat of disease. An abnormal increase of the acuteness of the olfactory sense is *hyperosmia*; an abnormal decrease, *anosmia*. Complete *abolition* of the sense sometimes takes place. It seems that for the development of smell the odorous particles must be transmitted to the nasal mucous membrane in a *gaseous* medium as the simultaneous contact of fluids destroys all appreciation of odor. Section of the olfactory bulbs entirely destroys the sense of smell. Injury to the fifth nerve may also destroy smell even where the olfactory nerve remains intact. This is probably only an indirect cause, however. This may be plausibly explained as the result of a deficiency in the secretion which is controlled by this nerve branch.

The delicacy of the sense of smell is determined in experimental work sometimes by an *Olfactometer.* For a description of this instrument as well as the process of using it see "Les Odeurs. Demonstrations avec l'olfactometre et le pésevapeur, par M. C. Henry," Paris, 1892. According to the writer of the above, most of the perfumes are of organic origin. There seems to be some relation between the odor and the atomic weight, more or less independent of chemical composition. It is further supposed that perfumes are propagated by the emission of solid, liquid or gaseous particles; hence the laws of diffusion and evaporation may largely control not only the degree of delicacy of the sense of smell, but perhaps also the apparent modalities. At any rate these are fruitful fields of research.

6. Ziehen says that the number of *modalities of smell* is very great as compared with the modalities of taste, although there is at present no good classification of the former. The specific names of odors almost always are taken from the odorous objects, or borrowed from the nomenclature of some other sense (as violet, rose, sweet, dry, etc.) With most persons the sensation of smell is exceedingly subjective, and any natural classification is made on this basis. This sense is always very closely associated with the well-being of the individual. The sense of smell is poorly localized in the higher animals, but is very closely associated with the cognitive powers and consequently is better localized in some lower animals. Indeed it almost takes the place of a natural language and takes the place of hearing in some cases. The word "taste" is often used when the word "smell" should be employed. We speak of tasting odoriferous substances such as onions, wine, etc., when in reality we only smell them as we hold them in the mouth. This is proved by the fact that the so-called taste of these things is lost when the nose is held or the nasal membrane rendered inert by catarrh.

7. *Central Olfactory Nerve Connections.* Methods of extirpation and subsequent histology have shown that the hippocampus is the olfactory region or centre in the brain. Moreover we find in aquatic animals (fish, dolphin, whale, sharks, rays, etc.) that the entire olfactory lobe is absent, and find in

semi-aquatic animals which frequent the water most that the hippocampus and radices are correspondingly reduced. The whole region in the limbic lobe below the rhinalic fissure is given up to the somatic senses in general, and to smell more especially.

The olfactory fibres probably do not develop from the olfactory lobe, but rather take their origin from the epithelium of the olfactory pits. It is likely that they originate primarily from the cells of the spinal ganglion as they bud out from the region of the neuro-pore. All evidence goes to show that they grow in from without rather than in the opposite manner. In the earliest stages the olfactory pits have no nerves. Later there is noticed a slight proliferation in the direction of the nerve tube. And it is just at this point that lack of decisive evidence makes it uncertain whether the olfactory nerve derives its fibres from the olfactory ganglion only or whether there is an interaction, fibres also growing out from the tuber. The former seems most likely. The tuber at its cephalic extremity, i. e. the bulb, in general, consists of two well-defined portions called the *pero*, the thick, outer, fibrous, buskin-shaped layer, and the *pes*, the inner, cellular layer. The pero is formed by the fibres of the olfactory nerve which diverge over the surface interlacing and commingling, thus forming the above-mentioned sheath-like cap enveloping the pes. The pes may be called the cerebral part of the bulb since no fibres pass from it without into connection with the olfactory epithelium. The adhesion of the pero to the pes is apparently of a secondary character, being probably mechanical, without any morphological connection. The internal structure of the pero would seem to show the same. The fact that the fibres lose their sheaths in their passage through the pero, but acquire them at their exit, would also attest it. (*Journ. Comp. Neurol.*, Vol. II, Feb., '92, pp. 2-7.)

The inner structure of the olfactory bulb may here be noted briefly. Passing entad we encounter successively the following layers: first, the fibrous outer layer consisting of apparently irregularly disposed fibre clusters, intercrossing confusedly, (i. e., fibres of the olfactory nerve); second, we come to the so-called glomerulary layer where are probably manufactured the myeline sheaths of the nerve-fibres and where the terminal dendrids of the fibres of the olfactory nerves enter into relations with those of the protoplasmic processes of the cells of the next, or ganglionic layer; third is found the ganglionic layer of pyramidal cells whose axis cylinder processes unite to form the radices lateralis and mesalis. The fourth and last layer of the pero consists of dense stratified granules. The pes consists of small fusiform cells like those of the hippocampal lobe, which goes to prove its central origin. It is from this layer that the large and circular bundle of radix entalis arises.

From these two portions of the olfactory bulb arise three bundles of fibres which pass backward, and in the case of two of them, at least, into certain definite relations with the hippocampus, and whose course is the occasion at present of so much discussion. The largest of these bundles, known as the *radix lateralis* from its position on the lateral aspect of the tuber, arises from the pero, or the outer layer. This bundle has been traced with comparative accuracy back to its cerebral connections in the hippocampus. The fibres of the radix lateralis gather in the granular layer of the pero, about the tip of the ventricle and on the ventral aspects of the tuber; pass ectad along the outer surface, spread out over and dip into the hippocampal region. They connect here with the ectal region of the hippocampal lobe. The *radix mesalis*, so called because it arises on the inner aspects of the tubers, and thus approximates the median line, has been traced into the indusium, the so-called striæ Lancisii, (Fish, No. 7.) It arises from the pero. This bundle is small as compared with the outer radix lateralis and is not so compact, being dispersed over the inner and ventral aspect. It has been found to pass to the gyrus fornicatus in the opossum, which is the cephalic part of the hippocampus. Beyond this its fibres have not been traced with any degree of certainty. The fact is here to be noted that the radix lateralis arising from the lateral aspect of the pero ends in the hippocampus without any morphological deviation in its course, while the fibres of radix mesalis arising from the median aspect of the pero pass dorsad of the callosum when the latter is present as striæ Lancisii to the hippocampus, and in the absence of the callosum (opossum) directly dorsad to the gyrus fornicatus. Into and through the anterior commissure and thence possibly to the hippocampus pass also the fibres of the third bundle, the *radix entalis*. This is the bundle which arises from the pes proper and in no case appears to enter into connection with the olfactory cells.

In the lower types, as the fish, there is only a rudiment which can be homologized with hippocampus of the higher forms. This homology has been traced by following the course of the radix lateralis as it passes in the fish to this point. In the higher types this is seen to be more distinct, while in reptiles the typical folds of the hippocampal gyre begin to assume their characteristic complexity. In mammals this folding becomes exceedingly complex, thus making the tracing of the fibres from the olfactory lobe very difficult. The lobe in the occital region of the cerebrum in the brain of reptiles which contains the undoubted homologue of the hippocampus is called by Edinger the ammon cortex. A comparison of the reptiles with the opossum and rodents in general shows that the only difference lies in the extreme complexity of the relations in the higher types which obscures the homology. The problem now is to trace the three radices back to the hippocampal region in all these types and completely homologize these different parts; to explain the relative position of these bundles, accounting for their migration and perversion by determining, among other things, at just what point lies the evolutionary front of the head. Another point of interest is the fact that recent investigators have shown that the first centres of the olfactory nerve lie in the pero of the bulb, and that from this point there migrate inward nerve filaments which come into connection with out-going fibres from the cortical centres. Thus the fibres connecting the bulb with the cortex acquire a new significanee and may be homologized with the projection or irradiation fibres of the optic centres which connect with the occipital cortex.

The olfactory nerves in *man* enter the nasal epithelium through some twenty openings in the bony arch and then branch into a perfect meshwork of fibrillæ, their extremities reaching to unite with the minute cells of the epithelial layer. Other accessory nerve-bundles which which supply the olfactory organs are, a branch of the ophthalmic (V), filaments from the anterior dental branch of the superior maxillary, the vidian, naso-palatine, descending anterior palatine, and nasal branch of Meckel's ganglion.

8. *Function of Jacobson's Organ.* Notice that among animals which live more or less on, or near, or burrow in the earth, such as ruminants, rodents, lizards, snakes, amphibians, etc., *Jacobson's organ* is more or less developed, while the nose is simple and comparatively undeveloped; while among animals that live entirely or mostly in the water, and in general among those animals who do not bring the nose to the ground, and do not depend upon the sense of smell in the search for food, as in man, birds, fishes, crocodiles, chelonia, etc., we find Jacobson's organ undeveloped or only rudimentary, while the nose proper is often quite complicated in its structure.

Again, glands seem abundant in water-livers, and more scarce in land-livers. Compare the difference even between the groups of Reptilia where you would not expect so marked a difference. Chelonia and Crocodilia are well supplied, while there is a comparative paucity of glands in Lacertilia and Ophidia. The *function of Jacobson's organ* is to determine directions, perhaps. Others suggest that it may consist in bringing the food taken into the mouth under the direct control of the olfactory nerve. In Reptilia for example, the function of Jacobson's organ seems to be to perceive odors of food during mastication. In man these functions, whatever they are, are evidently assumed by the turbinal convolutions.

II. Cartilaginous Investment.

Born and Solger have given good accounts of the anatomical relationships of the olfactory organ, in its relation to the bones of the cranium, the skeletal parts of the nose, etc. The olfactory cavity is first enclosed with a cartilaginous or bony investment in *Elasmobranchii. Polypterus,* the most highly developed of the fishes, has a complicated system of folds around a spindle. These compartments increase the surface of the cavity, a nerve passing to each fold. In *Dipnoi and Perennibranchiata* there is an external perforated cartilaginous capsule. In *Amphibia* true turbinals first appear, processes of the cranial skeleton which serve to increase the epithelium exposure. These spaces and cavities attain to considerable development in *Anura.*

Born has very fully dealt with the bony environment as found in adult Anura, taking *Rana esculenta* as an example. In *Crocodilia* and onwards, the olfactory organ is situated farther backwards, the posterior part lying immediately below the brain. In *birds* we have one true turbinal and two pseudo-turbinals, while in *mammals* the surface is increased by three methods; the formation of the hard and soft palate, the development of the turbinal bones, and the formation of the accessory cavities of the nose.

The type chosen in the present studies for delineating the nasal cartilaginous investment in Amphibia is a specimen of Urodela, *Amblystoma punctatum* taken at about the time of the metamorphosis. The description of the type before us is based on a close comparison of the specimen under investigation with the description of the investment of an adult *Axolotl,* and *Amblystoma opacum* which is a North American species developed from an Axolotl form. This description is found in "The Morphology of the Skull," by W. K. Parker, (No. 20.)

The broad flat *inter-nasal* tract of cartilage in Figs. 1-15, Plate V, occupies only about one-third of the longitudinal axis of the skull, while its breadth is approximately the width of the head. It has a concave margin behind, in which is lodged the fore part of the brain. The anterior margin is also concave where the two trabecular cornua separate. The olfactory crura pierce the shelving front wall of the cranium (in the internasal plate) just on the inner surface. The cartilaginous processes of the nasal plate nearly meet externally and in one case actually connect on the lateral aspect of the olfactory cavity. (See Fig. 7, Plate V, *in.*) The external nares are bounded in front by the incurved anterior cornu, and above and below by the dorsal and ventral cornua of the internasal plate.

The *pre-maxillary*, seen in cross section (*in*, Figs. 1-10, Plate V), sends a process backward over the internasal and overlapping for a short distance the frontals, (see *px*, Figs. 5-10, Plate V). The nasal processes of the pre-maxillary meet in the middle line through almost their whole extent, in this type, so that the internasal cartilage is not visible from above, and the membranous space which in other examples exists in front of the cartilage, is reduced to a fissure. This bone does not, as in Axolotl, surround the olfactory cavity upon its external aspect, but seems to be pushed dorsad and above, its lateral investing function being usurped by the large maxillary seen at *mx*, Figs. 7-15, Plate V.

The premaxillaries do not develop a palatal plate, but the *maxillaries*, which are very much lengthened backwards toward the mandibular articulation, have an inturned edge which Parker describes as a rudumentary platal plate. The maxillaries have also a short nasal process extending dorsad and backwards. (See Figs. 9, 10, 11, Plate V.)

The *naso-lachrymal*, as seen in Fig. 19, Plate V, *nl*, just after it emerges from the general cavity of the nose, is found lying encased on three sides by the maxillary; and by two small processes of the nasal, forming for a short distance a slight groove in which it rests. This complete envelopment in the investing cartilages is well shown under a higher power in Fig. 5, Plate VI. This position it retains until it approximates the surface of the head, when it lies in a slight depression in the nasal. Finally as it bifurcates on its approach to the eye (Figs. 13-15, Plate V, *nl*) it lies entirely free just beneath the surface of the skin.

The *frontals* are seen in Figs. 5-15, Plate V, at *f*. Each frontal is overlapped by the nasal process of the pre-maxillary, (*px*, Figs. 5-10,) by the nasal (Figs. 13-15, *n*) and by the ectethmoid (not shown in figures, lying as it does farther caudad).

The frontals appear to be larger than the parietals which they partially overlap; the parietals lying just in front of the auditory capsule are not represented in the figures.

The *nasals* (Figs. 6-15, *n*) are wedged in between the nasal process of the premaxillary in front, and the ectethmoid behind, meeting the maxillary at different points laterally. The nasal, like the frontal bones, is closely applied to the cartilaginous plate and olfactory capsule, but does not graft itself upon the cartilage so as to ossify it. A general knowledge of the relations of the investment in the different types of Amphibia under discussion may be gained by a comparison of the various drawings of models and sections; especially see Plates X-XII.

III. Naso-lachrymal and Glands.

The general relations of the *naso-lachrymal* in Amphibia, to the apparatus which corresponds to it in higher vertebrates has been amply discussed by Born (No. 4.) We here briefly describe it as we have found it in different types, and from drawings of our own.

The *Naso-lachrymal* duct conducts the lachrymal secretion from the conjunctival sac of the eye into the nasal cavity. This duct is found in some cases as a shallow furrow which runs downward to the upper margin of the mouth. This stage is the permanent condition in many *Selachians,* and is found in the embryonic stages of some higher types. (See European salamander, below.)

The naso-lachrymal duct in *Salamandra atra,* European salamander, at first where it has its origin in connection with the eye, (within the inner lower lid of the eye) passes as a naso-lachrymal sinus for most of the way until it comes into the vicinity of the olfactory cavity where it dips beneath the surface passing for a short distance as a closed duct. See model, Fig. 1, Plate XI, *nl, or, op, ey*; dorsal view, as also of Amblystoma, Fig. 3, Plate XII. This duct then suddenly drops ventrally ending in a ventro-lateral diverticle of the cavity at *or.* This is seen in Fig. 1, *nl,* Plate VI and Fig. 2, Plate XI, *or,* and Fig. 1, Plate XI, *or.*

This tube appears in cross-section also as a mere group of cells arranged as seen in Fig. 2, Plate VI, *nl*, *epit* etc. A series of cross-sections shows this tube to consint of a mere grouping of cells with an illy defined duct within. The cells are arranged in a circular manner leaving this space within which opens above into the groove and below into the lumen of the diverticle. This is shown at a later stage in Amblystoma, Fig. 5, Plate VI, *nl*. From the general cavity of the nose there projects a lumen into this diverticle, which is continuous with the tube of the above mentioned duct. This duct then passes laterad, dorsad, and caudad as above described. The eye-ball, *ey*, is much reduced comparatively, and shows roughly the reconstruction of the bifurcated opening of the naso-lachrymal upon the lower eye-lid. In this figure (Fig. 1, 2, Plate VI) the tube is situated just below the epidermis and can be followed for several sections quite distinctly until it emerges upon the surface as a groove or furrow. See Fig. 1, *nl* and *op*, Plate XI.

Under a high power the cell-walls may be discovered of these epithelium cells as well as of the characteristic connective-tissue cells with which they are surrounded (Fig. 2, *epit* and *con*, Plate VI). An outer layer of epithelium cells intervening between the true epithelium and connective-tissue cells have beome flattened and adhere to the outer sides of this tube. See also Fig. 5, *epit* and *con*, Plate VI. Surrounding it is, further, the fibrous tissue which binds the tubular structure somewhat to the skin beneath which it lies. Chromatophores line the skin here very abundantly. See *pig*, Figs. 1, 2, Plate VI. This abrupt change in the course of this duct appears almost entirely within three or four sections (which are not more than 15-20 micromillimeters thick.) At this stage the lachrymal glands are not developed to any extent, which accounts for, or correlates with the undeveloped condition of the duct. As seen in the other types the duct here also divides into two tubes for a short distance before entering upon the open surface of the lower lid (*op*, shown also in Figs. 3, 4, Plate XI.)

This diverticle, out of which the naso-lachrymal leads, may be homologized with the smaller outer, upper diverticle found in tadpoles (*od*, Fig. 5, Plate X; also Fig. 5, Plate XI.) A close homology will be seen to exist between this type and other Urodela. See Figs. 3, 4, *nl*, *or*, *op*, *ey*, etc., Plate XII.

A very similar condition and relative position for this duct is seen to exist in *Amblystoma punctatum.* Its entire course from the point where it originates upon the lateral aspect of the cavity from its peculiar diverticle (see *or*, Figs. 3 and 4, Plate XII) to its opening upon the lower lid of the eye (*op*, Fig. 3, Plate XII) is seen in Fig. 3, Plate XII. Its course, as in Salamandra atra, is in general parallel to the longitudinal axis of the nasal cavity. Having its origin just behind and a little mesad of the exterior nares it courses backward, ending just dorsad and a little laterad of the internal nares.

Fig. 3, Plate VI is a transverse section showing the origin of the naso-lachrymal, *nl*, from the general cavity of the nose, *gen.* In this figure is seen the opening of the cartilaginous investment through which this duct makes its exit between the two internal processes, *in.* The real tube of this duct can only be distinguished from the many gland ducts with which it is associated by this internal connection with the general cavity, *gen.* The structure of this duct, and the epithelium membrane which lines it is nicely shown in Fig. 5, Plate VI where it is revealed under a high power. In Amblystoma this duct appears at one point to be completely enclosed within the bony investment, but for only a short distance. See Fig. 5, Plate VI, *n* and *mx*. *Ey*, Figs. 3 and 4, Plate XII, as in S. atra, shows the eye much reduced, to illustrate the method of termination of the duct.

In adult Anura, *Hyla versicolor*, *Bufo lentigenosus*, *Rana virescens etc.*, the outer tip of the lateral cul-de-sac breaks through the investment (see Figs. 3 and 4, Plate VIII, *nl* and *or*) and makes its way through the bony environment in the form of a tube extending outward and backward toward the eye (*nl*, fig. 5, Plate VIII). In *Pelobates fuscus*, says Born (No. 4), the canal passes backward, as mentioned, only in this case enclosed in a tubular extention of the bone. In other Anura it lies in a mere hollow in the bone. From this point, as in the other cases, it passes in the direction of the under eyelid where it ends in two grooves which separately open upon the free margin of the inner half of the lid. In the larvæ they end on the inner side, while in the adult, as a rule, they end nearer the outer side of the lid.

"If in an adult frog you expose the three nasal cavities" says Born (No. 4), "it is easily possible to see in the section of the lateral sac a fine tubular connection" which may be recognized as the naso-lachrymal duct. How this tube closes up from its original position as a mere groove is not yet clear, but it is always so seen. The canal never appears in the adult as a groove but always as a closed cavity. It appears, on section, in connection with a black band, in the larvæ, which in *Rana esculenta* stretches from the eye to the nose. The canal passes out through the upper nasal glands, *up* (Fig. 3, Plate VIII), is widest nearest the nasal end and narrows on approaching the lid. This is nicely shown in *Bufo lentigenosus*, Fig. 1, Plate XII, *up*, *or*, *nl*. Its epithelium is, in general, of the same character as that of the lateral cul-de-sac.

The general relations of the naso-lachrymal in the adult *Rana virescens* were so nearly identical with those in *Hyla versicolor*, that the conditions as found in the latter only were modelled. It is essentially such as described by Born in his work entitled "Ueber die Nasenhöhlen und den Thränenasengang der Amphibien" (No. 4). These relations are modelled in Figs. 3, 4, Plate XI, at *nl*, *or*, *bi*, *up*, etc. Figs. 3-6, Plate VIII, *nl* and *or* are four camera-drawings which illustrate the methods of origin of the duct in both these types.

In *Bufo lentigenosus* modelled in Figs. 1 and 2, Plate XII, we find the naso-lachrymal originating as in all Anura from its own special diverticle, *lc*, upon the external aspect just behind the external nares, *extl*. In spite of the marked difference in the general configuration of the nasal cavity in this type as compared with other adult Anura, it is not difficult to homologize it with other types in this respect. See *nl*, *or*, *up*, etc., figs. 1, 2, Plate XII.

Born (No. 18) further has shown in the *lizard* and *chick*, at the base of the groove separating the nasal passage from the folds which represents the eyelids, a rod-like thickening of the epidermis which seems to be distinct from its mesodermic surroundings, and to resemble the naso-lachrymal duct; ending, as it does, in the lower eyelid, where as usual it splits in two, the outer branch not quite reaching the epidermis while the inner one does.

Glands.—Bowman's glands (in *Gymnophiona*) are grouped on the dorsal transition area of the olfactory organ where it bulges out to form what has been homologized with the Jacobson's diverticle. Burckhardt further distinguishes in this group what he calls Jacobson's gland which forms a richly branched meshwork at the base of the olfactory sac where it opens into the external nares, the structure being the same as the dorsal nasal glands.

These glands as seen in *Urodela* are well exhibited in Fig. 4, *gla*, Plate VI, *Diemyctylus viridescens*, where they are seen in connection with the diverticle *jd*, which is characteristic of this group. See also fig. 3, Plate VI, *gla*, *Amblystoma punctatum.* They are further shown in the different models lying, as they do, in their different relative positions in the different types.

In *Salamandra atra* they are seen in Fig. 1, Plate XI, *gla*, dorsal view of cavity, just a glimpse of them being obtained in this figure as they are hidden by the overarching projection of the premaxillary. In fig. 2, Plate XI, *gla*, which represents a ventral view of the same they are seen lying on the inner ventral aspect of the cavity at about the center of its longitudinal axis.

In *Amblystoma punctatum* they lie scattered more promiscuously along almost the whole ventral median aspect of the cavity as seen modelled at *gla*, Fig. 4, Plate XII. They are represented in the model by ridges or furrows. See also *gla*, fig. 1, Plate VII, also *gla*, Fig. 1, Plate IX and figs. 3-5, Plate V.

Born distinguishes in *Anura* four different groups of glands: two opening into the nasal cavity and two emptying into the mouth and throat respectively. The two latter, the intermaxillary and choanal, on account of their position, are not shown in the models. The former two are the upper and lower nasal glands. Born has fully discussed the position and structure of these different groups, we will here only indicate upon the model their position as found in several different types of Anura.

Figs. 6 and 7, Plate X, which are pen-drawings of wax models of right cavity of tadpole of leopard frog, *Rana virescens* show the glandular formation even at this stage, *gla*. It is observed that in this case as in most of the larval Anura the glands lie in close connection with the inner diverticle, *id* or *jd*.

Fig. 7, Plate XI, which shows the dorsal view of an older tadpole shows these glands lying upon the median aspect of the cavity supported below by the fundament of the internasal tract of cartilage, *in*. In this stage they have attained to larger dimensions than in those before referred to.

Figs. 3 and 4, Plate XI, are dorsal and ventral views respectively of model of nasal cavity of an adult tree-toad *Hyla versicolor*. In this stage both groups of glands are developed. The upper nasal glands are seen at *up*, fig. 3, Plate XI, the lower at *lo* in both figures. The latter are situated as in the larvæ upon the median aspect of the cavity but farther forward, relatively, in the adult. The former lie upon the latero-dorsal aspect just behind the anterior (or external) nares, *extl*. They are much smaller than the lower nasal glands.

In *Bufo lentigenosus* which is modelled in Figs. 1 and 2, Plate XII, are also seen the upper and lower groups of nasal glands, *up* and *lo*, situated relatively in the same positions as above described. They are modelled as adherring to the respective diverticles of the olfactory cavity for convenience and durability of the models.

The paucity of glands in *Lacertila* and *Ophidia* as compared with the other reptilia seems to be compensated by the greater development of Jacobson's organ, which being a smaller organ would not require such a profusion of glands. See Figs. 2, 3, 4, 5, 6, Plate IX, *gla* and *jo*. In *mammals* the Bowman's glands are diffuse.

IV. Innervation and Histology of the Epithelium of the Nose and Jacobson's Organ.

Histology of the Epithelium.—The olfactory epithelium is usually the simplest form of neuro-epithelium found in animals.

The single olfactory cells which are the first indications of a specialized sense-organ for smell, are the phylogenetic derivatives of the olfactory buds seen in the olfactory crypts in the adult higher forms. In almost all cases the olfactory epithelium is more highly developed on the side toward the brain, the thinner walls of neuro-epithelium lying upon the ventral and lateral surfaces. It is often lobed or corrugated also on the side nearest the olfactory bulb, where then erves enter. See Fig. 3, *cor*, Plate VII.

The uncertainty formerly existing in the minds of many investigators as to the exact nature of the termini of the olfactory nerve in the nasal cavity and in Jacobson's organ seems now to be quite satisfactorily removed. The concurrent testimony of so skillful investigators as Cajal, Van Gehuchten, Lenhossék, Brunn and Retzius, leaves but little doubt that the so-called olfactory cells of the olfactory epithelium and of Jacobson's organ are real nerve cells and that there is actual nervous continuity between the cilia at one pole and the fibre of the olfactory nerve springing from the other pole of these cells. Preparations recently made in our laboratory both by the Golgi method and by the hæmatoxylin process (and figured in Plate XIX, Figs. 1, 2, and 3; plate XX, Fig. 3, Journal of Comparative Neurology, September, 1893) prove conclusively, if additional proof were necessary, that the fibres of the olfactory nerve as they pass into the olfactory tuber break up into terminal brushes ("end-bäumchen") in the glomerules without coming into relation with any cells at this end of their course. In accordance, then, with the current morphological ideas of nervous structure, the peripheral neuron of the olfactory system would consist of the olfactory ganglion cell in the nasal membrane, its axis-cylinder process which forms one of the constituent parts of the olfactory nerve, and its terminal brush in the glomerule. See Current Views of the Structure of Olfactory Organs and Taste-bulbs, Journ. Compar. Neurol., III, Sept, 1893.

Previous investigators have discovered a difference in the nerve end-filaments as found in olfactory epithelium, as compared with the epidermal, optic, auditory and gustatory. They have claimed that in the former case the nerve filaments enter into immediate connection with the cells. Recently some authors have endeavored to show that filaments enter the cells of Corti in the ear, and the cells of the corium of the skin. But these investigators (notably Ayers and Pfitzner) have not made good their claims to the satisfaction of many, so that the olfactory epithelium still appears to hold its peculiar position in this respect.

Our own studies of the olfactory epithelium of trout, salamander and frog, confirm the general belief that there are two kinds of cells, the smaller sensory type, and the larger monliform supporting type. (Fig. 6, Plate VII ; Fig. 2, 4, 5, 7, *Frog*, *a*, Plate VII). The smaller cells (Trout) are probably as Max Schultze calls them, "the true olfactory cells." They consist of a nucleus and two long processes, the one ending upon the surface of the mucous membrane and ciliated, and the other passing back through the ganglionic nutritive layer and terminating in connection with a filament from the nerve-bundle. The larger supportive cells (Figs. 2-7, *b*, Plate VII) are also ciliated upon their free ends and as indicated by the term, moniliform, seem to consist of several cells superimposed upon one another, forming a bi- or tri-nucleated rod, as it were. That these are really several cells successively impinged one upon another, and not, as some seem to think, poly-nucleated single cells seems to be quite clearly demonstrated by a careful drawing of a portion of the olfactory epithelium in *Amblystoma punctatum*. See Fig. 2, *a*, *b*, Plate VII.

A peculiarity of the olfactory cavity of *Amblystoma* is the presence and marked development of numerous crypts formed by the deep folds in the olfactory epithelium (Fig. 1, Plate VII, *Cry*.) Between these and lying about and among them are the numerous small glands which seem to have their openings in the interspaces of the crypts. (Fig. 1, *gla,* Plate IX). This arrangement is seen in Fig. 6, Plate VI, in cross section, and in Fig. 1, Plate VII, longitudinal section. See also Fig. 2, Plate VII, *epi.*

The model of Amblystoma shows also transverse and longitudinal sections of the nerve-bundles supplying the olfactory cavity. They are shown on the model cut off obliquely as they enter the olfactory bulb. (Fig. 4, Plate XII, and in section, Fig. 6, Plate VI, *cn* and *ln.*) Fig. 1, Plate X, *oln,* represents the innervation of the nasal epithelium of the tadpole showing the nerve-bundle as it originates in the olfactory *bulb.*

The innervation and histology of Jacobson's organ is in general comparable to that of the nose proper. With regard to the innervation of Jacobson's organ it is probable that the division of the olfactory nerve into two branches is not as Wiedersheim and Marshall formerly believed, homologous with the two branches of a cranial nerve to each side of a gill-cleft, but a division into two bundles passing respectively to the nose proper and Jacobson's organ, and where no diverticle is present, completely homologous with the similar division where it is present (as in the Reptilia).

The sensory epithelium of Jacobson's diverticle in *Gymnophiona,* says Burkhardt, remains as in the embryonic condition without any tendency to form sensory buds as in the olfactory proper, which indicates a retardation as compared with the nasal epithelium.

In *Amphibia* in general the nerve-bundle for Jacobson diverticle passes to a little pit (the olfactory fossa) on the olfactory tuber with connections to the radix lateralis, as in Reptilia. The olfactory nerve of *tailed Amphibia* (salamander) corresponds in its relations to the cerebrum, decidedly, to the lower branches of the olfactory nerve of frog larvæ and Gymnophiona.

Beard, speaking of its histology in *Reptilia,* finds the nerve-fibres ending in the bases of the ganglionic columns which lie just within the true epithelium cells. He says distinctly that the nerve-fibres do not pass between the columns or crypts, but end at their base. In this he finds a close resemblance as in other respects to the olfactory epithelium proper. This crypt-like arrangement of the ganglionic columns of the olfactory epithelium as found in the Ophidia Beard also points out in an obscured situation in Lacertilia; and we have found it present also in several species of Amphibia. His conclusion in general is that Jacobson's organ in Lacertilia and Ophidia is a very highly specialized portion of the epithelium, and says that it, in these cases, at least, must be an incomparably finer sense-organ than their nose proper (No. 1.) On the structure of Jacobson's organ we have investigations by Klein, Leydig, Wright, Born and Solger, but as to the important question of its real nature and origin these are sadly deficient.

V. Evolution and Development of Jacobson's Organ in Particular.

Jacobson's Organ is without doubt as Beard says, "a specially differentiated part of the nose." It was discovered by Jacobson, the Danish anatomist, at the beginning of the present century. We will here endeavor to make a comparison of the different types possessing what we think to be the fundament or proton (Anlage) of a Jacobson's organ. In general it is safe to assert thst no Jacobson's organ appears in any type lower than fishes, if indeed in fishes there can be found any true homologue of Jacobson's organ. In *Polypterus*, indeed (the most highly developed of fishes) there is a short distinct oval sac in the median line which has no connection with the rest of the olfactory, and which receives a special branch of the olfactory nerve, but it is doubtful if this is to be homologized in any sense with the true Jacobson's organ as found in the higher types.

In *Caecilians* there is a sac having a separate opening in the mouth, but this is to be homologized with the maxillary sinus (air-chamber) of higher vertebrates. Jacobson's organ is described by one author as a paired accessory nasal cavity, which in an early embryonic stage becomes entirely separated off from from the nasal chamber, and which is supplied by the olfactory and trigeminal nerves; it communicates with the mouth by a special aperture. This definition applies accurately to the accessory nasal chamber of *Caecilians*, already mentioned; in no other vertebrates, however, does it retain the character of a kind of separate nasal chamber, but on the contrary, the higher we pass in the vertebrate series, the more does the maxillary cavity become separated physiologically from the olfactory organ; it loses its olfactory epithelium and finally degenerates into a simple air-sinus.

Beard says that the so-called Jacobson's organ of *Gymnophiona* is not homologous with that of Reptilia but only a secondary olfactory organ, while the two-fold division of the olfactory nerve, though comparable, is yet not homologous with the condition found in Reptilia. Again Wiedersheim in his attempt to homologize the outer diverticle which he found in *Gymnophiona* (*Ichthyophis*) with the Jacobson's organ of Reptilia, found the difficulty confronting him that this diverticle appeared upon the outer side whereas in every case the true Jacobson's organ has been found lying on the inside of the nasal cavity proper. He therefore concludes that there is no homology or if there is he confesses the difficulty, while Beard denys the possibility, calling it a secondary olfactory organ, to prevent confusion.

Our studies lead us to an entirely different conclusion. We believe that this diverticle which Wiedersheim found, is in the original position of the primitive Jacobson's organ as an outer diverticle, and that in the course of its evolution it revolves from without, inward (i. e. from laterad, entad) until it holds the position seen in other Amphibia and Reptilia: viz. on the median aspect of the olfactory cavity proper. This, of course, would place Gymnophiona in this respect lower than Anura and possibly lower than Urodela in the phylogenetic series. There is some evidence, indeed, for believing that Urodela are but an arrested stage of a higher type—a higher amphibian arrested permanently in its larval condition. At any rate the adult conditions as found in Urodela are undoubtedly a transition stage from Gymnophiona and Caecilians and other lower types of Amphibia to Anura and the higher types.

The Sarasin brothers have some time since suggested that a diverticle of the nasal cavity of the salamander larva and newt may be homologous with this so-called Jacobson's organ of Gymnophiona, but no researches had yet been made. Burckhardt suggests that possibly the salamander is derived from forms which originally possessed a Jacobson's organ. We think it more likely that the salamander is a transition stage, as above suggested, in which the diverticle, which is the fundment or proton of Jacobson's organ, is not yet separated to act as a distinct organ.

Figs. 3 and 4, Plate XII, represent dorsal and ventral views of the model of the right nasal cavity of the American salamander, *Amblystoma punctatum*. Contrary to the general configuration of the nasal cavity of the frog, tadpole, etc., the curvature presents its convex surface toward the median line, or vice versa, its concave aspect is laterad. This peculiarity of curvature is constant among salamanders: see the model of European *Salamandra atra*, Figs. 1 and 2, Plate XI, drawings, etc. This curvature brings the external and internal nares toward the lateral line, whereas in the tadpole the internal nares are further toward the median line. The relative position of the nares in the *adult* frog or tree-toad is more nearly comparable to the condition in Salamandra both larval and adult. In following through a series of transverse sections of the nasal cavity of this type, we find the diverticle, which we attempt to homologize with the Jacobson's organ of higher types, lying quite laterad: see Figs. 3 and 4, Plate XII, *jd*; and Figs. 8, 9, 10, Plate V.

In *Salamandra atra* this diverticle lies more ventrad: see Fig. 2, Plate XI, *jd*; while in larval Anura it lies on the ventral median aspect: see Figs. 7 and 8, Plate XI, *jd*; and Fig. 5, Plate XI, *id*. In adult Anura it seems to become partly obscured by the change in external configuration;—the crowding forward and shortening of the longitudinal axis of the whole cavity. But even there it remains discoverable in the light of this homology, being confused by some authors with the so-called maxillary sinus which does not occur in its true form in the amphibian nasal apparatus.

Fig. 1, Plate XI, is a representation of a directly dorsal view of the right nasal cavity of a larval European salamander (*Salamandra atra*). Essential points of resemblance are immediately observed to exist between this European type and Amblystoma. The model as above figured is enclosed in its cartilaginous investment and so the complete homology is partially obscured; but in fig. 2, Plate XI, which shows the same model from a ventral view the points of resemblance are more fully brought out. Although the exterior shows some difference in general configuration, the European being narrow and thick and rounded, broad and flat and much thinner in comparison; yet the relative situations of the different parts are the same. It must also be taken into account that the former is a model of the larval cavity while the latter is a model of the cavity of an adult Amblystoma. The comparison of the investmental relations brings out still more markedly the difference in the comparative age of the two specimens (compare Figs. 1-15, Plate V, with *in* and *px*, Figs. 1, 2, Plate XI). The model of the European salamander is much more highly magnified, absolutely, than that of Amblystoma. The internasal plate is not as yet completely united along the median line, while the only one of the external cartilaginous plates which was sufficiently differentiated to be modelled was the pre-maxillary which sends back its overarching process as seen in Fig. 1, Plate XI, *px*.

There remains to be remarked the correspondence in the position of the curious *diverticles* which are present in each case. One of these, the nasolachrymal, *or*, is discussed elsewhere. The other is seen in section, Fig. 1, Plate IX, *jd*, and is figured upon the model at *jd*, Fig. 2, Plate XI.

From camera drawings upon sheets of wax (the same method has been followed in all) the model figured in Fig. 6, Plate XI, was constructed to show the right olfactory cavity of a young tadpole, larval, body length 5 mm, leopard frog, *Rana virescens*. At this early stage the nasal sac consists of a general cavity with its two diverticles and its external and internal nares, *od*, *id*, *extl* and *intl*, Fig. 6, Plate XI, and Fig. 5, Plate X. The general curvature of the organ from its external to its internal terminus is with its concavity mesad. In the proximity of the internal opening it is characterized by a great thickening of the epithelial wall (Fig. 3, Plate X, *t*). On the outer aspect of the cavity among the rather irregular modifications of the epithelium wall, an outer small diverticle is apparent which is quite distinct from the mere corrugations of its surface. See *od*, Figs. 1, 2, Plate VIII, 2 and 5, Plate X, and Fig. 6, Plate XI. This diverticle is evidently transitory as it does not appear in either of the older specimens (Figs. 6 and 7, Plate X, and Figs. 7, 8, Plate XI). On the inner aspect midway between the nares, rather ventral than dorsal, and somewhat lower and further forward than the smaller outer diverticle, is situated another and larger diverticle which, as has been hinted, may be homologized with Jacobson's organ in higher types (Reptilia etc.) See Figs. 2, 3, 5, 6, 7, Plate X, and Figs. 5, 6, 7, 8, Plate XI, *id* and *jd*. Large and apparently active glands lie immediately dorsad and in close connection with the diverticle, having also close connection with the general cavity, in the epithelial interspaces. See Figs. 6, 7, Plate X, Figs. 6, 7, Plate XI, *gla*, *epi*.

Fig. 6, Plate X, represents the inner aspect of a model of an older tadpole, over a centimeter in length, of the same species; *jd* represents in this figure the inner larger diverticle homologous, as we believe, with Jacobson's organ in Reptilia. Fig. 7, Plate X, shows a view of the same model looking down from above as it would be situated in its place within the right side of the head of the tadpole. The marked difference between the model figured in Fig. 5, Plate X, and Fig. 6, Plate XI, and this one, lies in the disappearance of the outer smaller diverticle, and in the comparative enlargement of this inner larger one with its glands (Figs. 6 and 7, Plate X, *gla*). The difference in the absolute size of the models, as in the other cases is due partly to the fact that lenses of different degrees of magnification were used to make the camera drawings in the different cases, and partly to the real differences in the sizes of the specimens under investigation.

In Fig. 1, Plate X, we have a camera sketch of a horizontal section through the right cavity of the tadpole modelled in Fig.

5, Plate X, and Fig. 6, Plate XI, revealing the entrance of the olfactory nerve-bundles from the olfactory tuber, *oln.* This view corresponds to a section of the model taken at D, Fig. 5, Plate X. In this section the opening in the cartilaginous fossa, *in,* shows the bundles in their connections with the *bulb.* Fig. 2, Plate X, is a section taken more ventrad, represented on the model as a section at E, Fig. 5, Plate X. This horizontal section shows the opening from the general nasal cavity, *gen,* into the outer smaller diverticle *od,* also the external nares *extl,* and the upper wall and very small beginning of the lumen of the cavity of the larger inner diverticle, *id.* In Fig. 3, Plate X, represented by a section of the model taken at B, Fig. 5, Plate X, we see the opening of the general cavity *gen,* into that of the inner diverticle, *id.* Also we see the great thickening of the inner wall, *t,* in the vicinity of the internal nares. It seems to be constant throughout that the wall becomes thickened on the inner, median side probably due the fact that it is on this side that the nerve termini make their closest connections. It is also on this inner aspect of the nasal cavity that corrugations generally appear, due perhaps to the entering, at different points, of distinct nerve-bundles. Fig. 4, Plate X, shows the internal nares, *intl,* and is represented by a section of the model in the plane indicated at C, Fig. 5, Plate X. Here again we notice the thickened inner epithielium wall, *t.* In Fig. 1, Plate VIII, we have a horizontal section of another specimen than the one modelled, from which the previous drawings were taken. This tadpole was also somewhat younger, but sufficiently similar to make comparisons with the same model. Here is seen the outer diverticle in a slightly different plane upon each side of the head, *od,* and also the external nostril, *extl,* upon the right side. A section taken at A, Fig, 5, Plate X, would show such a view as this. Fig. 2, Plate VIII, is a drawing of a transverse section also of a younger specimen, showing the opening into the lumen of the outer diverticle, *od,* and also showing a nerve-bundle entering upon its median-dorsal aspect, *oln.* Such a view would appear in a section of the model taken in the plane indicated at F, Fig. 5, Plate X.

The amphibian *Anura* during embryonic life are, as we have said, possessed of two diverticles, an outer upper lateral and an inner lower mesal one. Says Balfour (Compar. Embryology, No. 8), "a diverticle of the cephalic portion of the nasal cavity of *Anura* (frogs) is probably a rudiment (proton) of Jacobson's organ." Fleischer finds the likeness between the lower diverticulum of Anura (embryos) to the Jacobson's organ in reptiles and describes its subsequent probable development in the following words: "In the course of further development, (after the diverticulum stage), it passes further downwards and in doing so gets turned about its axis, so that the canal by means of which it was still connected with the nasal cavity comes now to open into the mouth cavity." We think it probable as before suggested that not only is this true, but that there has taken place a previous revolution from its external (lateral) position ventrad and mesad from the position which it occupies in Gymnophiona and some salamanders until it reaches the position as found in tadpoles, and further that this process is carried on beyond the stage mentioned by Fleischer until the diverticle comes to lie entirely mesad and as a separate organ (now known as Jacobson's organ). These remarkable changes in relative position are made strongly probable moreover by the corresponding shortening of the head, seen in its progressive stages corresponding to the advancing revolution of the diverticle. Beard is inclined to doubt the complete homology throughout, but our own researches in these various types seem to confirm the suggestions of Götte, Fleischer, Born, and Kölliker who have hinted at this homology.

A cross-section through the nasal sac in an adult frog, in front of the internal nares, reveals three cul-de-sacs. The first is an upper wide and rounded cavity, the second a smaller lateral sac opening into the naso-lachrymal duct, and the third a lower smaller cavity communicating with the mouth by the internal nares and with the so-called maxillary sinus by an oblique cleft. The inner nares open into the mouth from the most lateral point of this maxillary cavity. In the higher types we find that this maxillary sinus, by the elongating of the palate, opens not directly as here, into the oral cavity, but into the general cavity of the nose proper. These relations are well shown in the model of *Hyla versicolor*, Fig. 4, Plate XI, and Fig. 5, Plate VIII.

In the *lizards* Jacobson's organ is described as a small paired cavity lined by olfactory epithelium from the floor of which a papilla arises. This papilla is shown in Fig. 6, Plate IX, in *Eutænia*, and in Fig. 3, Plate IX, *pap.* It communicates with the mouth by a special aperture in front of the internal nares. See *Eutænia*, Figs. 3 and 4, Plate IX, *ap.* Beard (No. 1) says "It is now a fact that Jacobson's organ of reptiles is a specially differentiated part of the nose" but that "it must be an incomparably finer sense-organ than their nose proper." It is best developed and most functional in *Lizards*, Figs. 2-6. Plate IX shows these general relations in Reptilia, in Eutænia and black snake embryos. It is noticeable that in Lacertilia the parietal eye and Jacobson's organ are both functional, whereas in Anura and Urodela (Amphibia in general) both are degenerated or undevoloped, The question arises whether the diverticle is a degenerated Jacobson's organ, or Jacobson's organ a developed and perfected diverticle. We incline to believe the latter to be the true statement of the case. There is a remarkable gap in this respect between the two groups of Reptilia, Ophidia and Lacertilia on the one hand and Chelonia and Crocodilia on the other hand; the former possesing a Jacobson's organ so highly differentiated and the latter possessing only a rudimentary organ which until recently has defied detection in *Crocodilia.* This discovery was made by C. Rose, "Ueber das rudimentäre Jacobson'sche Organ der Crocodile und des Menschen." Anat. Anz. VIII, 14, 15, June, 1893. (No. 22.)

Further the two groups in which Jacobson's organ is well developed are, aside from its development, endowed with a very simple nose proper as compared with the conditions as found in Crocodilia and Chelonia. It appears that these two things were related in some way. Perhaps the nose proper of these two groups has a simple structure because of the high development and extreme delicacy of their Jacobson's organ, and Crocodilia and Chelonia on the other hand are recompensed for the absence of any functional Jacobson's organ by the much greater complexity of their nose proper.

Jacobson's organ is very general in *mammals* especially rodents, ruminants, perissodactyles, where it exists as a mere tube ending blindly posteriorly and opening anteriorly into the mouth by the ducts of Stenson (or naso-palatine canals). A small depression on the median wall of the nasal pit in mammalian embryos is the proton of Jacobson's organ. The external nose of mammals is derivative of the outer chamber mentioned in Caecilia. The Jacobson's organ of *man* lies high up, far above the basales narium cartilage, which has its usual position.

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a.—true olfactory cells.
ap.—aperture of Jacobson's organ communicating with the mouth.
b.—supportive olfactory cells.
bc.—blood corpuscles.
bi.—bifurcation of nasolachrymal duct.
c.—olfactory terminal cilia.
cn.—transverse section of nerve-bundle.
con.—connective tissue cells.
cor.—corrugations of olfactory epithelium.
cry.—crypts in olfactory epithelium
ep.—epidermis.
epi.—epithelial interspaces.
jo.—Jacobson's organ.
lc.—lateral cul-de-sac in adult Anura.
ln.—longitudinal section of nerve-bundle.
lo.—lower nasal glands in Anura.
loc.—lower cul-de-sac in adult Anura.
mc.—mouth (oral) cavity.
mx.—maxillary plate.
mxc.—maxillary cavity.
n.—nasal plate.
ncc.—nasal capsular cartilage.
nl.—naso-lachrymal duct.
od.—outer smaller diverticle in larval Anura.

epit.—epithelial cells.
extl.—external nares.
ey.—eye.
f.—frontal plate.
gen.—general cavity of nose.
gla.—glands.
id.—inner larger diverticle, in larval Anura same as *jd.*
in.—internasal cartilaginous plate.
intl.—internal nares.
d.—homologue of Jacobson's organ, same as *id.*
oln.—olfactory nerve.
olnb.—olfactory branch from V nerve.
op.—opening of naso-lachrymal duct upon lower eyelid.
or.—origin of naso-lachrymal duct.
pap.—papilla of Jacobson's Organ.
pig.—pigment cells.
px.—premaxillary plate.
t.—thickened part of epithelium.
up.—upper nasal glands in Anura.
upb.—upper cul-de-sac in adult Anura.

DESCRIPTION OF PLATES V–XII.

PLATE V, FIGS. 1 to 15.

Series of camera drawings of cross-sections of the investmental cartilages in head of adult *Amblystoma punctatum.*

PLATE VI, FIGS. 1–6.

Fig. 1. Transverse section of embryo *Salamandra atra*, showing nasolachrymal in its origin and dorsal passage toward its emergence upon the epidermis.

Fig 2. Camera drawing of the same, further caudad, showing the naso-lachrymal duct in cross-section as it lies just beneath the epidermis.

Fig. 3. Camera drawing of nasal cavity of *Amblystoma punctatum*, showing entrance of naso-lachrymal duct, glands, etc.

Fig. 4. Camera drawing of olfactory cavity of *Diemyctylus viridescens*, showing glands and their connection with the olfactory cavity.

Fig. 5. Camera drawing of naso-lachrymal duct of *Amblystoma punctatum*, showing its position in the cartilaginous investment, also the histology of its epithelial lining.

Fig. 6. Camera sketch showing a portion of nasal cavity of *Amblystoma punctatum*, showing nerve bundles in cross-section, also in longitudinal section; and showing the crypts in the olfactory ganglionic layers.

PLATE VII, FIGS. 1–7.

Fig. 1. Camera drawing of longitudinal section of nasal cavity of *Amblystoma punctatum*, showing crypts, glands, external nares, etc.

Fig. 2. End-cells, *Amblystoma punctatum*, illustrating the formation of the so-called moniliform supportive cells; *a*, true olfactory (sensory) cells. *b*, supportive cells.

Fig. 3. Camera drawing of longitudinal section of nasal cavity of *Diemyctylus viridescens*, illustrating the corrugations and crypt-like involutions of the olfactory epithelium.

Fig. 4. Olfactory end-cells of *Rana virescens*; *a* and *b*, as above.

Fig. 5. Same, showing connection with nerve filaments.

Fig. 6. Sensory end-cells of olfactory epithelium of *Trutta fario*.

Fig. 7. Same as Figs. 4 and 5.

PLATE VIII, FIGS. 1–6.

Fig. 1. Camera drawing of horizontal section of right and left nasal cavities of tadpole, younger than the one figured in Fig. 5, Plate X, as young as that figured in Fig. 5, Plate XI. This section is indicated for convenience upon the same model as the above. See at A, Fig. 5, Plate X.

Fig. 2. Camera drawing of transverse section of right cavity of younger tadpole, as young as that figured in Fig. 5, Plate XI; plane of section indicated as above in Fig. 5, Plate X, at F.

Fig. 3. Camera drawing of transverse section of right olfactory cavity of *Hyla versicolor*, showing origin of nasolachrymal.

Fig. 4. Camera drawing of same, showing nasolachrymal as a duct in cross-section.

Fig. 5. Same, showing inner ventral diverticle, also nasolachrymal.

Fig. 6. Same, showing internal nares.

PLATE IX, FIGS. 1–6.

Fig 1. Camera drawing of a portion of nasal cavity of *Amblystoma punctatum*, showing Jacobson's diverticle, the nasolachrymal duct in cross-section and a portion of the general nasal cavity.

Fig. 2. Camera drawing of transverse section of nasal sac and Jacobson's organ of *black-snake* embryo.

Fig. 3. Camera drawing of longitudinal section of *black-snake* embryo, showing nasal sac and Jacobson's organ opening into the mouth cavity.

Fig. 4. Same, showing Jacobson's organ opening into mouth cavity.

Fig. 5. Same, showing nasal sac completely enveloping Jacobson's organ.

Fig. 6. Camera drawing of horizontal section of nasal sac and Jacobson's organ of *Eutenia*, showing papilla projecting into the lumen of Jacobson's organ.

PLATE X, FIGS. 1-7.

Fig. 1. Camera drawing of horizontal section of right nasal cavity of tadpole, *Rana virescens*, modelled in Fig. 6, Plate XI, and Fig. 5, in this plate. The plane of this section is indicated on the model in Fig 5, at D.

Fig. 2. Camera drawing of horizontal section of same. Plane of section seen at E.

Fig. 3. Camera drawing of horizontal section of same. Plane of section seen at B.

Fig. 4. Camera drawing of horizontal section of same. Plane of section seen at C.

Fig. 5. Pen sketch of directly lateral view of model of right nasal cavity of medium-sized tadpole of leopard frog, 5 mm. long, *Rana virescens* ; constructed from horizontal sections, magnified 1000 diameters. A, B, C, D, and E, indicate the planes of the sections shown in Figs. 1-4, Plate X, and Figs. 1 and 2, Plate VIII.

Fig. 6. Pen sketch of median view of model of right nasal cavity of still older tadpole of leopard frog, *Rana virescens*, built up from perpendicular sections. Magnified 450 diameters.

Fig. 7. Pen sketch of directly dorsal view of same.

PLATE XI, FIGS. 1-8.

Fig. 1. Crayon sketch of dorsal view of model of right nasal cavity of *Salamandra atra* (European salamander) ; larval, just born, 16 mm. long; magnified 120 diameters.

Fig. 2. Crayon sketch of ventral view of same.

Fig. 3. Crayon sketch of dorsal view of model of right nasal cavity of *Hyla versicolor.* Constructed from transverse sections, magnified 227 diameters. This shows the three cul-de-sacs from before.

Fig. 4. Crayon sketch of ventral view of same.

Fig. 5. Crayon sketch of model of right nasal cavity of very young tadpole, *Rana virescens*; showing, even at this stage, the external and internal nares, and the inner and outer diverticles.

Fig. 6. Crayon sketch of ventral median view of model of right nasal cavity of medium-sized tadpole, *Rana virescens* ; showing internal and external nares, glands, and inner larger diverticle. Compare Fig. 5, Plate X.

Fig. 7. Crayon sketch of directly dorsal view of model of left nasal cavity of tadpole of *Rana virescens*, quite old, legs one mm. long. Constructed from transverse sections, magnified 150 diameters.

Fig. 8. Crayon sketch of ventral view of same.

PLATE XII, FIGS. 1–4.

Fig. 1. Crayon sketch of lateral view of model of right nasal cavity of *Bufo lentigeninosus.* Constructed from horizontal sections; magnified 80 diameters.

Fig. 2. Crayon sketch of median-ventral view of same.

Fig. 3. Crayon sketch of directly dorsal view of model of right nasal cavity of *Amblystoma punctatum;* constructed from transverse series of sections; magnified 400 diameters; specimen one centimeter long.

Fig. 4. Crayon sketch of ventral view of same showing anterior and posterior nares.

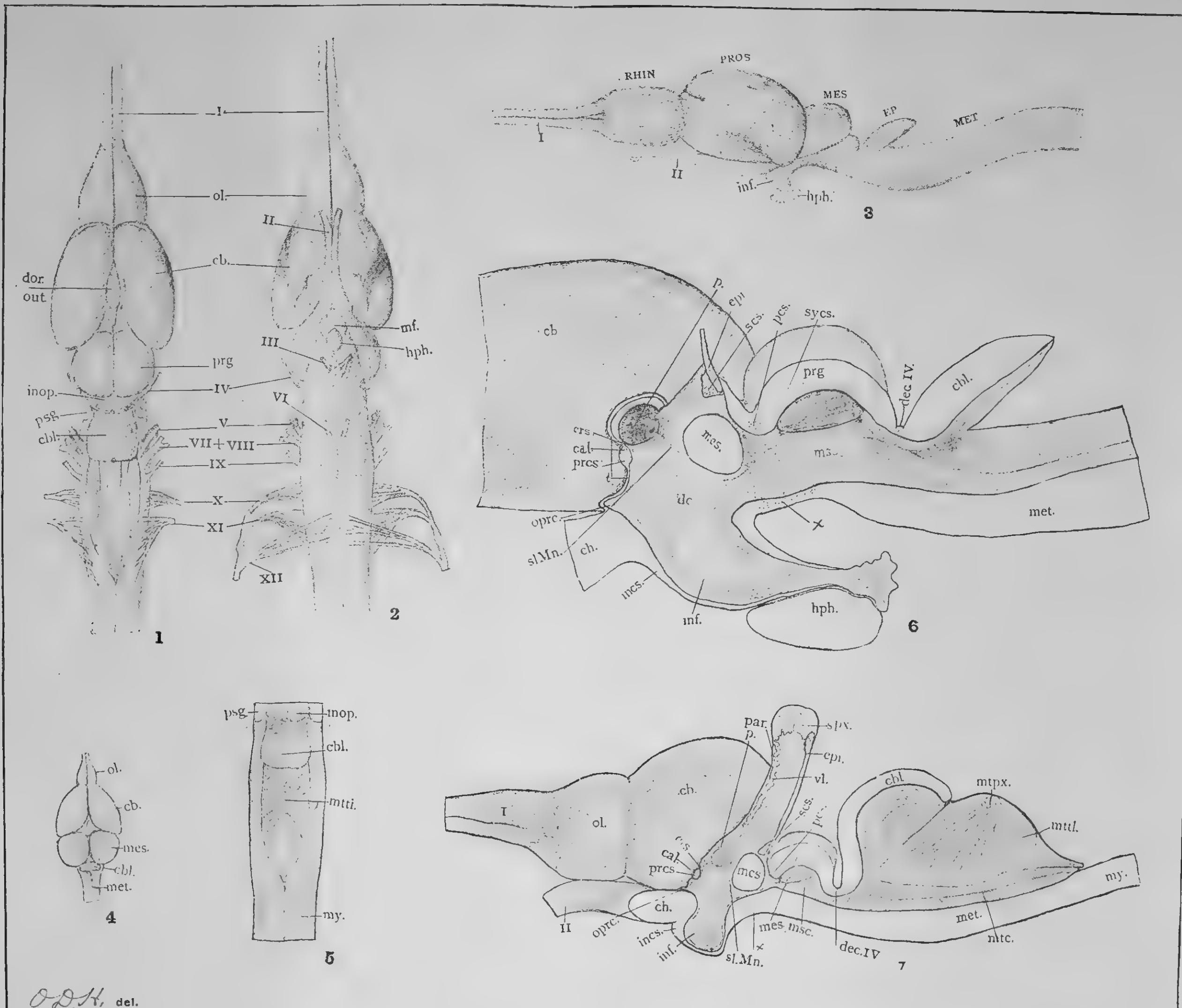
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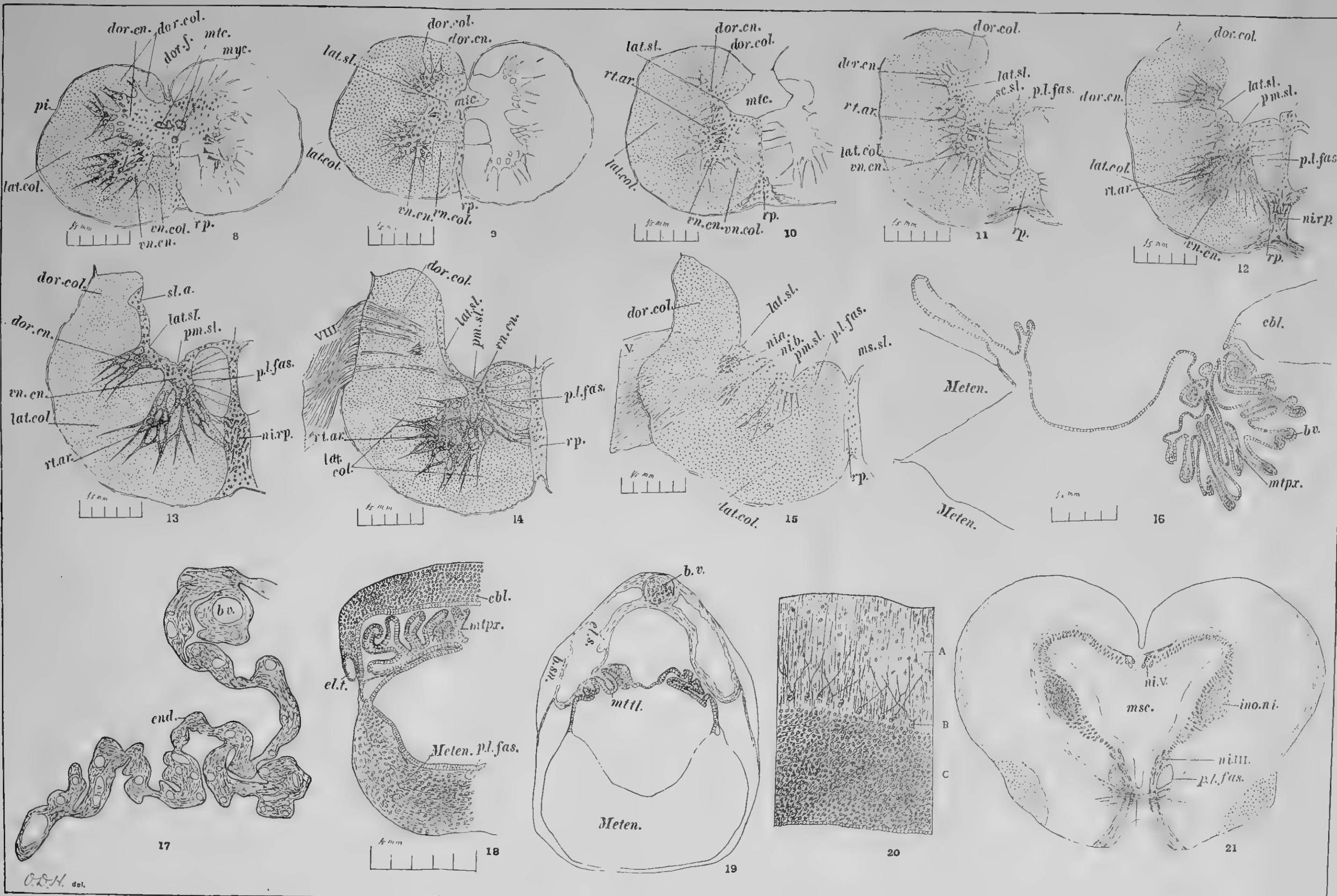
PLATE III.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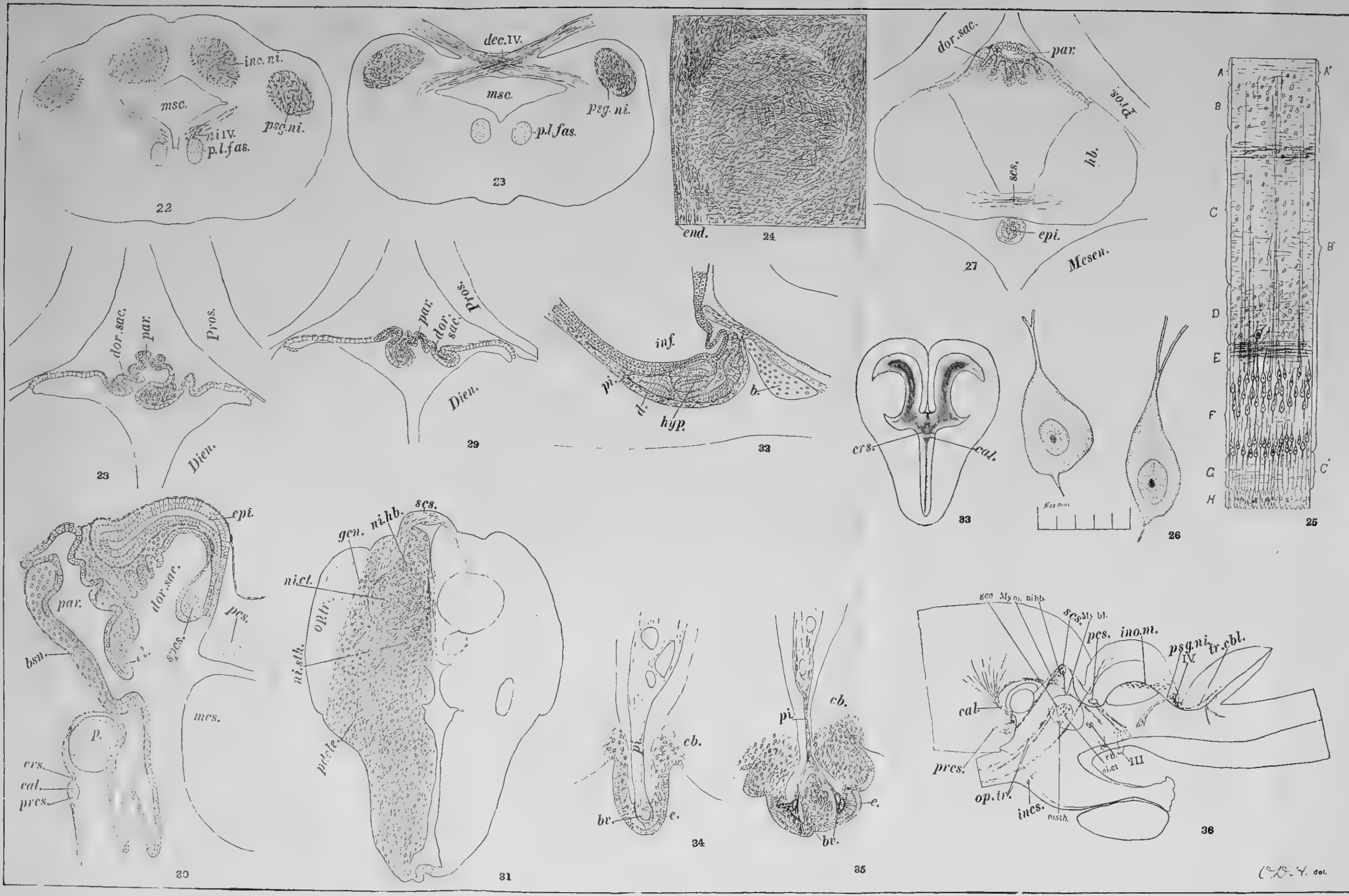
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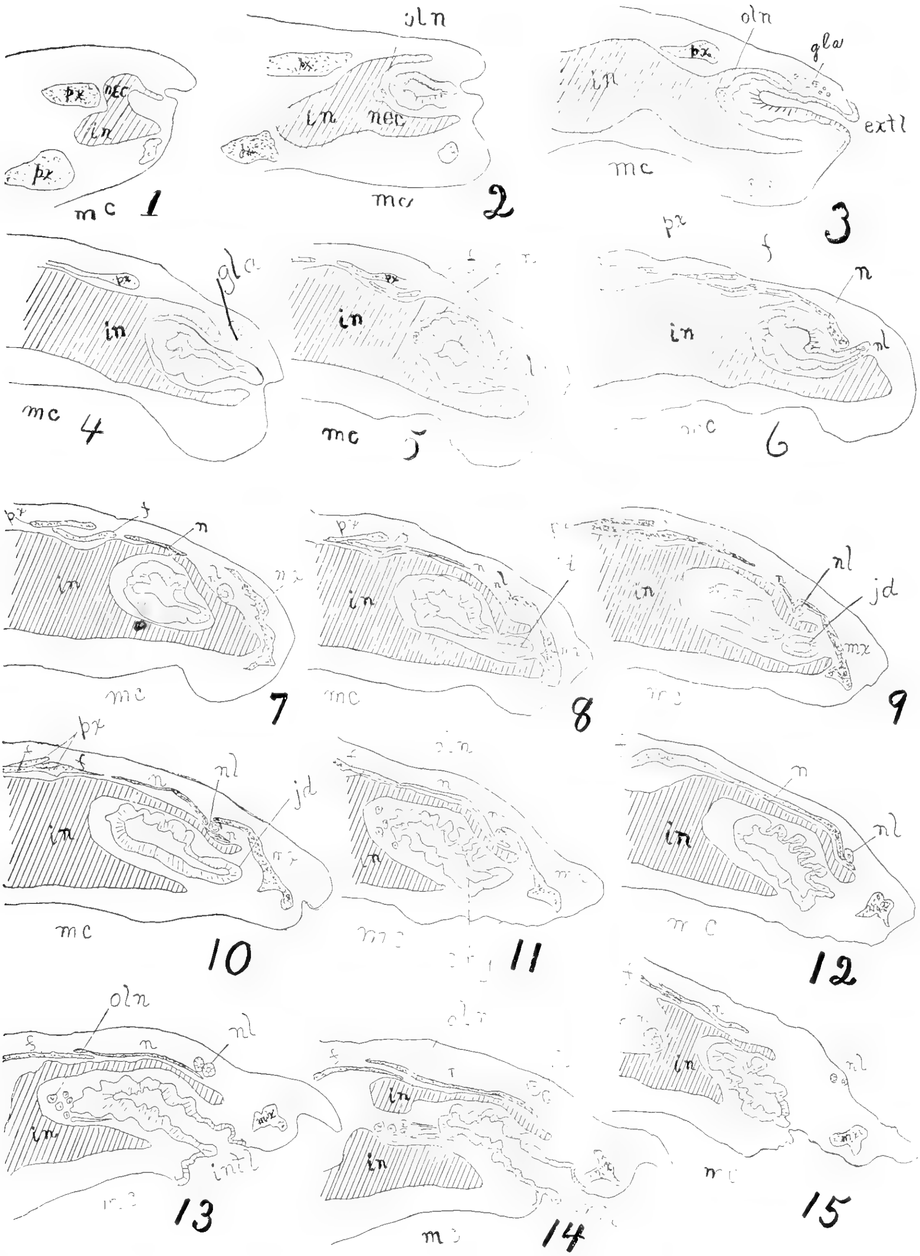
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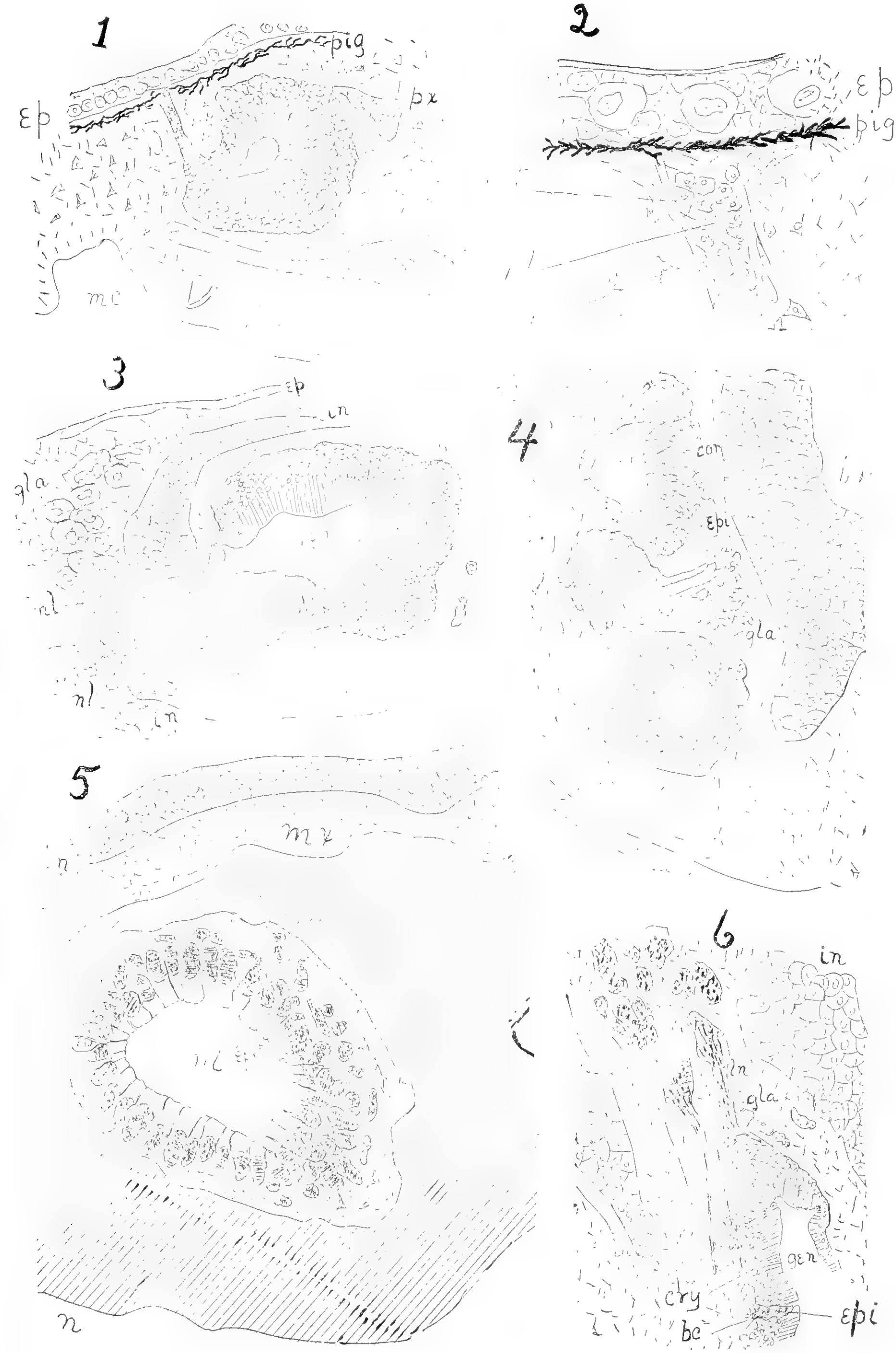
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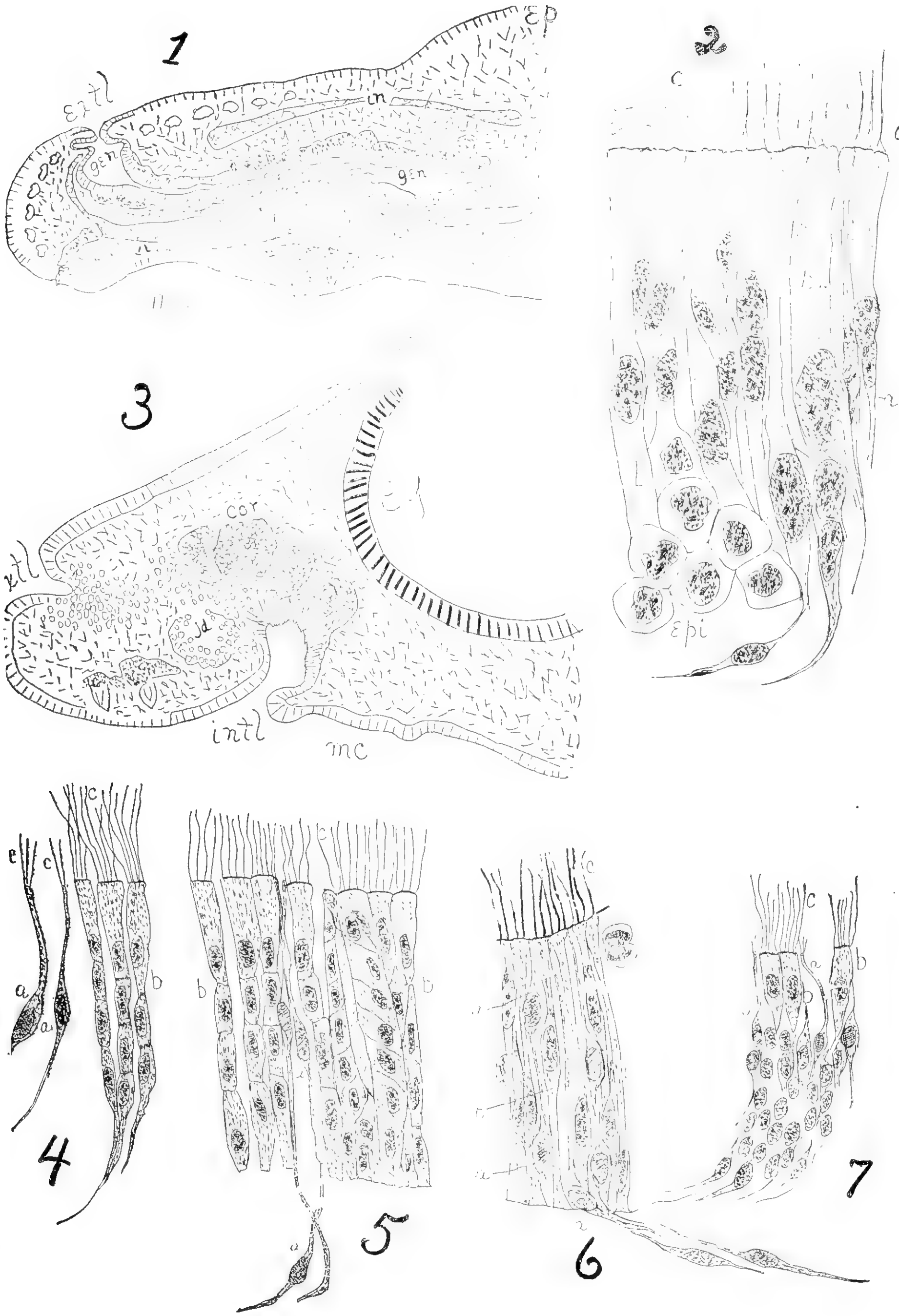
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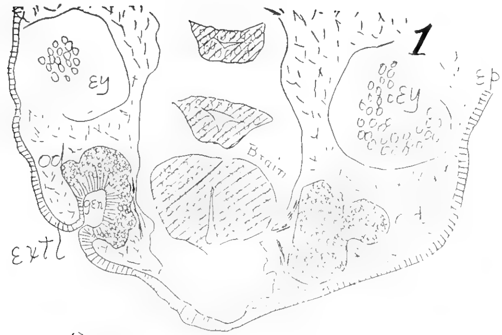
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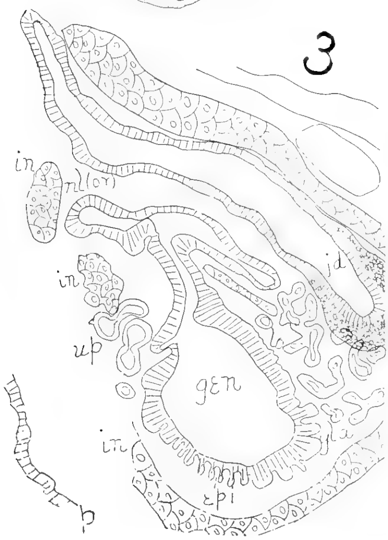
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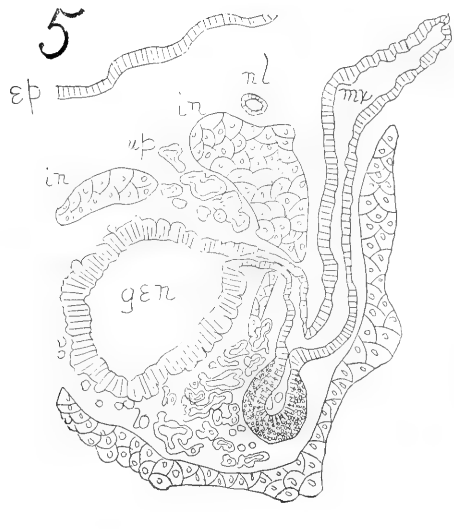
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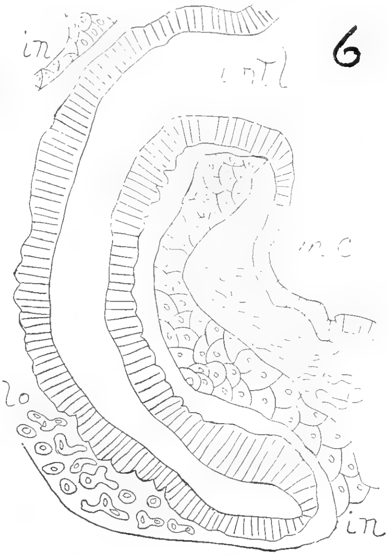
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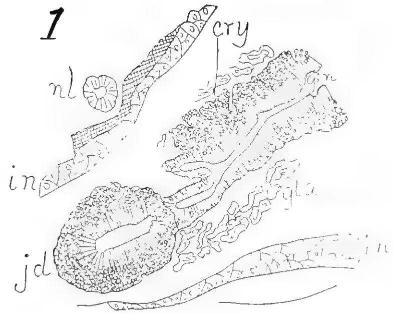
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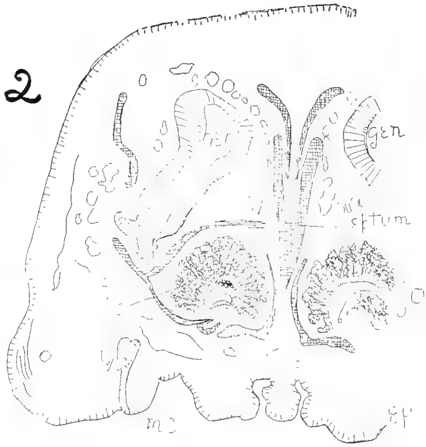
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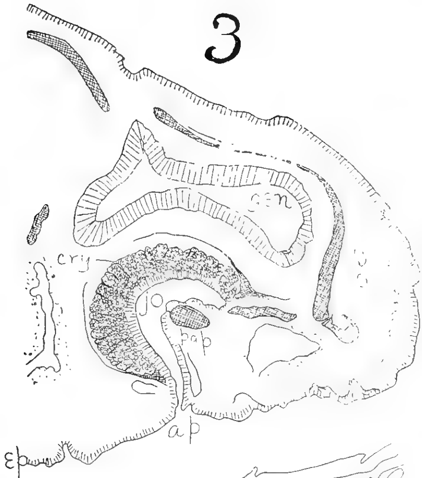
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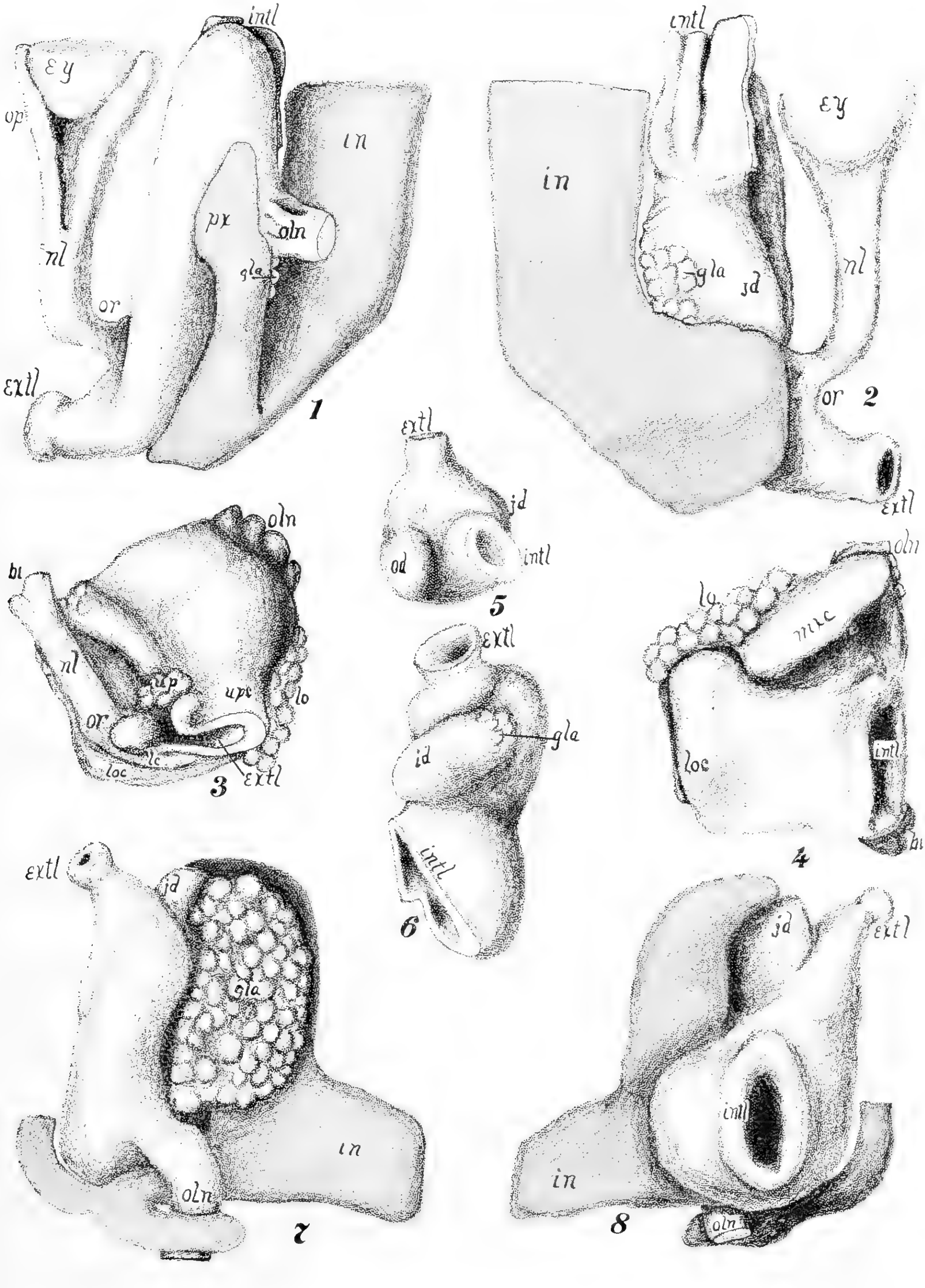
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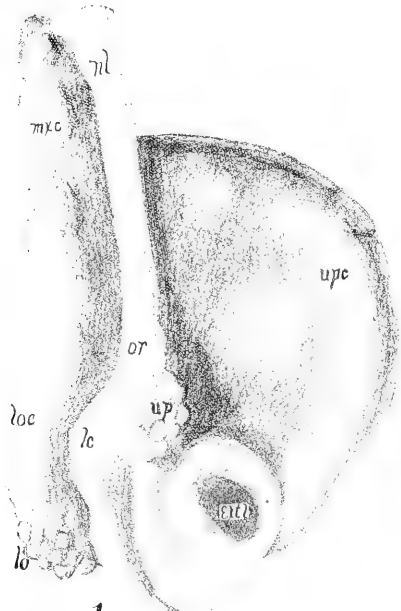
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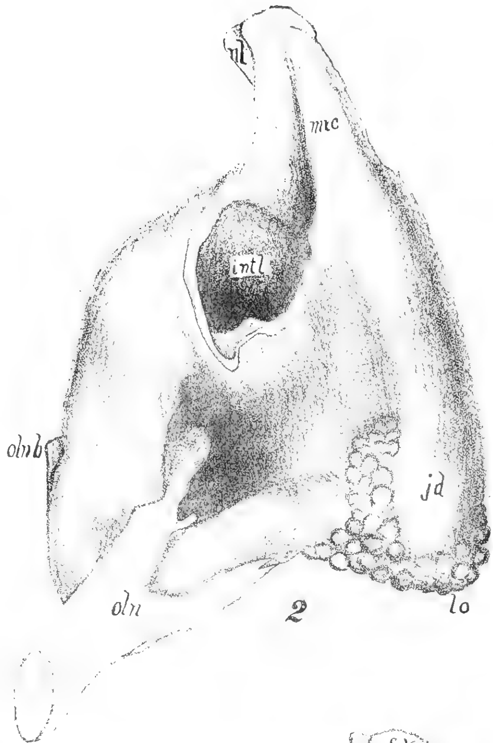
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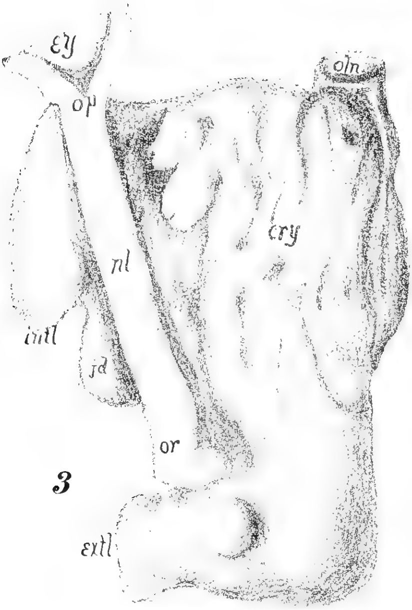
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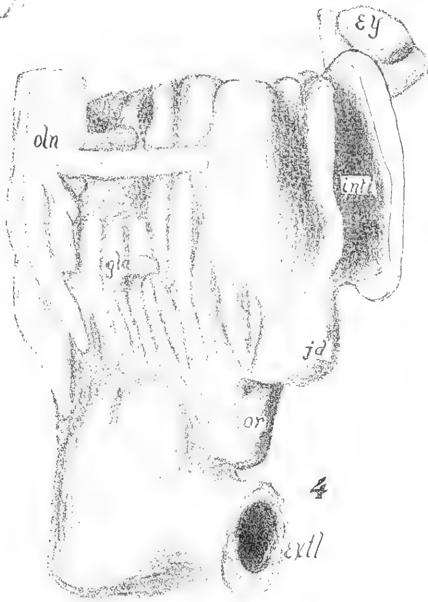
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STUDIES FROM THE NEUROLOGICAL LABORATORY OF DENISON UNIVERSITY.

IX. Comparative Study of the Epiphysis and Roof of the Diencephalon. Continued.

By A. D. Sorensen, A.B.
Fellow in Neurology.

Since our "Historical Account" appeared a few important papers have come to hand and for the sake of completeness their points of interest and importance are here given.

Kupffer (*99*–'93) figures the roof of the diencephalon of Salamandra maculosa and Rana temporaria schematically, and gives the following description: In the tadpole the parietal organ is not only separated but also considerably removed from the pineal. The plexus choroideus medius is evaginated from the anterior lamella of the transverse velum in a spheroidal

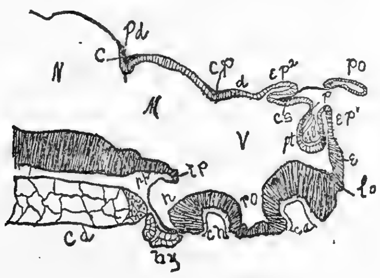

Fig. 1.

V, Vorderhirn; *M*, Mittelhirn; *e*, Grosshirn Epencephalon; *p*, Nebenhirn Parencephalon; *d*, Schalthirn Diencephalon; *h*, Unterhirn Hypencephalon; *pd*, plica encephali dorsalis; *pv*, plica encephali ventralis; *c*, cerebellum mit seiner commissure; *ca*, comm. anterior; *ch*, chiasma opticum mit den comm. post-opticae; *cp*, comm. posterior; *cs*, comm. superior; ep^1, Vordere Epiphyse oder Paraphysis; ep^2, Hintere Epiphyse oder Zirbel; *lo*, Lobus olfactorius impar; *ro*, Recessus opticus; *tp*, tuberculum posterius; *vt*, Velum transversum des Vorderhirnes; *cd*, Chorda; *hy*, Hypophysis; *po*, Parietalorgan.

form. On the roof of the prosencephalon in amphibians there are five parts: three dome-like vesicular projections, and two stalked epiphyses. The anterior member (*e*) may everywhere be recognized with certainty as pertaining to the cerebrum. In front it connects with the lobus olfactorius impar and posteriorly is bounded by the velum transversum, immediately in front of which arises the first stalked projection or paraphysis (ep^1). The second division (*p*) corresponds to the parencephalon which, as in the sturgeon, extends from the velum to the supra-commissure. Behind the latter is the fourth member, the pineal (ep^2). Thus far there is a complete similarity to the sturgeon. But now instead of the post-commissure a fifth division appears, an arched segment (*d*) behind which lies the post-commissure. The author regards this as homodynamous with the first and third portions, and calls it 'Schalthirn Diencephalon.' It is therefore impossible to assume two homodynamous segments, each with a pallium, a stalked epiphysis and a commissure. Perhaps some organs have disappeared in the phylogenetic development.

Charles Hill (*34*–'91) describes two epiphyses in the embryo of white-fish, one behind, strangulated cross-wise so as to give the impression of a double pineal situated on a single stalk, and the other in front, making its appearance two days later, whose place of origin is plainly removed from the post-plexus. The pre-plexus lies close to the post-commissure in front; it corresponds therefore to the well-known pineal in bony fishes. Kupffer was inclined to consider the front plexus as the paraphysis but Hill says explicitly that it lies behind the fold, which the wall of the prosencephalon gives off, hence behind the portion designated by him as velum transversum.

Susanna Gage (*98*–'93) studied the epiphysis and paraphysis of Diemyctylus and writes: The epiphysis of Diemyctylus like that of other urodeles is insignificant. In embryos it is prominent, in the early stages a remnant of its connection with the brain remains occuring as usual between the supra- and post-commissures. In the adult this connection has disappeared and its cavity is nearly obliterated. From its caudal end a few fibres pass toward the roof of the mesencephal. From the degenerate condition it would be impossible to determine whether these are nervous or connective tissue elements. In the Amia as in other ganoids, the epiphysis lies to the left of the meson, owing to the greater development of the right habena. The stalk can be traced through a tortuous path to its union with the brain. In the lamprey, the connection of the stalk with the brain is very clear. The pigment of the organ is white by reflected light, agreeing with Beard's description (*4*–'87). The white pigment extends from the floor of the epiphysis into the hollow stalk for some little distance, then the stalk becomes inconspicous and passes between the two habenæ to its union with the brain at the left of the middle, but on a morphological meson. The paraphysis in Diemyctylus forms a very irregular sac lying in the midst of the supra-plexus. The opening is upon the meson between the blood vessels supplying the dia- and auli-plexuses. This opening is not into either diacœle or aula but marks the boundary between the two. In Amia the dorsal sac is reflected from the supra-commissure with a diverticulum extending caudad over the supra-commissure and habenæ. The stalk of the epiphysis arising caudad of the supra-commissure is thus brought into contact with the dorsal sac and continues cephalad upon it or partly enclosed in it and from this arrangement the term *second vesicle of the Epiphysis* has been applied (*Zirbel-polster* of German writers).

W. A. Locy (*51*–'93) has studied the derivation of the pineal and gives the following summary:

1. There are preserved on the cephalic plate of Elasmobranchs (Squalus acanthias) at least two pairs of accessory optic vesicles.

2. These taken with the primary optic vesicles give to the embryo three pairs of rudimentary eyes.

3. The anterior pair develop into the lateral eyes and the first accessory pair form the walls of the thalamencephalon and give rise to the principal outgrowths from it.

4. The epiphysis is therefore double in origin forming from a united pair of accessory optic vesicles.

5. Since the latter are homologous with the lateral eyes their derivation is also homologous with the lateral eyes. The differences in structure of the epiphysis need to be explained.

6. It is highly probable that the enlarged distal end of the epiphysis in Squalus is homologous with the pineal eye in those forms in which it is differentiated.

In a later article Locy confirms his previous observations and adds that he has been able to trace with certainty the anterior pair of accessory vesicles into the pineal outgrowth. It thus appears that the pineal outgrowth arises from two pairs of vesicles that are homologous witn those giving rise to the lateral eyes.

A. Prenant (*70*–'93) in addition to historical references to the work of Duval and Kalt, Leydig, and Carriére, who alone, and independently have found accessory eyes, gives four statements as the result of his observations, as follows: 1. The accessory eyes are found in a single species, *Anguis fragilis*; 2. They are limited to the embryonic period; 3. they present in the embryos great variability in their constitution; 4. they are not constant.

Rudolf Burckhardt (*9*–'93 and '94) draws the relations in the embryo of Lacerta vivipara 1.3 cm. long, which is here reproduced.

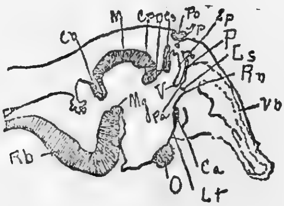

Fig. 2.

Ca, Commissura anterior; *cb*, Kleinhirn; *cp*, commissura posterior; *cs*, commissura superior; *D*, Shaltstück; *Ls*, Lamina supraneuroporica; *Lt*, Lamina terminalis; *M*, Mittelhirndach; *Mg*, Grenze der Mittelhirnbasis; *Np*, Nebenscheitelorgan; *O*, Opticus; *P*, Paraphysis; *Pa*, Ursprung der Plexus hemisphaerium; *Po*, Scheitelorgan; *Rb*, Rautenhirnbasis; *Rn*, Recessus neuroporicus; *V*, velum; *Z*, Zirbel; *Zp*, Zirbelpolster.

In another number he gives a perpendicular section through the brain of a larva of Petromyzon fluviatilis, 4.2 cm. long, which is also reproduced.

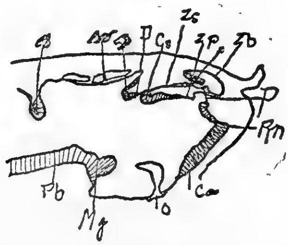

Fig. 3.

ca, commissura anterior; *cb*, Kleinhirn; *cp*, commissura posterior; *cs*, commissura superior; *D*, Shaltstück; *Md*, Mittelhirndach; *Mg*, Grenze der Mittel; hirnbasis; *O*, Opticus; *P*, Paraphyse; *Rb*, Rautenhirnbasis; *Rn*, Recessus Neuroporicus (Lobus olfactorius impar); *Zb*, Zirbelbläschen; *Zp*, Zirbelpolster *Zs*, Zirbelstiel; *z*, Ahlborn's "unteres Zirbelblsächen."

PERSONAL INVESTIGATION.

In the following work the object has been to make a comparative study of the epiphysis and roof of the diencephalon in as many types as have been at our disposal. We are not sure that the ground covered has been sufficiently exhaustive to draw many conclusions, yet we have been struck by the great similarity between the relations found throughout the different groups from the fishes to the mammals. Among the fishes the following have been studied: Ictalurus lacustris, Lophius piscatorius (Fishing frog), Lucioperca, Trutta fario, Hyodon, Cycleptus elongatus, Scaphirhynchus platyrhynchus, Lepidosteus, Blicca, Belone.

The epiphysis of Ictalurus lacustris has been studied and described by C. L. and C. Judson Herrick (*31b*–'91) and by C. Judson Herrick[1] but without drawings showing the exact relations of the various parts. For this purpose we have made drawings from two different series available (Plate XIV, Figs. 2-4). Fig. 2 is a perpendicular section showing the origin of the epiphysis immediately caudad of the supra-commissure. It

[1]Kansas Academy of Science, '91-'92 p. 71.

is a long tubular projection from the diencephalic roof and rests upon the slightly folded plexus beneath. Figs. 3 and 4 are transverse sections of a young catfish one inch long, cut through the entire body, which show the epiphysis and also a vesicle lying immediately beneath and in contact with the skull roof. There can be no doubt from the structure and position of this vesicle that it has its origin from the distal end of the epiphysis and is perhaps the rudiment of a primitive optic vesicle, as C. Judson Herrick has observed.

Plate XIV, Fig. 1, shows a horizontal section of Lophius. The sections were imperfect and only the epiphysis with its relation to the roof could be found.

Figs. 10 and 11, Plate XIV, are transverse sections of the epiphysis of Lucioperca. Its origin from the third ventricle is not shown, but by comparison with other fishes there can be no doubt that the epiphysis is evaginated from the roof of the diencephalon and assumes the usual tubular structure and form. The folded plexus is seen lying immediately below the tube of the epiphysis.

Fig. 7, Plate XIII, is a perpendicular section of the epiphysis and related parts of the trout (Trutta fario). The epiphysis is well defined and presents the appearance of a vesicle with diverticles from its walls. It arises immediately caudad of the supra-commissure, which consists of two separate bundles, and is still in open communication with the ventricle. The plexus upon which the epiphysis rests has only a single fold presenting a very simple structure. Dorsad of the epiphysis will be seen a bony structure.

In Hyodon we found the same structures and relations which obtain in Cycleptus as described below.

Figs. 7-8, Plate XIV, show transverse sections of the epiphysis of Cycleptus elongatus. From its origin caudad of the supra-commissure the epiphysis runs forward over the plexus, which is slightly folded, through forty sections. It retains its tubular structure and form throughout its entire length.

The structure of the roof of the diencephalon of Scaphirhynchus (Plate XIII, Figs. 5, 6, and 8,) and of Lepidosteus

(Plate XIII, Figs. 1 to 4) have been fully described by C. L. Herrick (*31c*–'91) and are here reproduced merely for the sake of comparison.

Two other fishes have been studied, namely Blicca and Belone. In Blicca (Figs. 9, Plate XIV) a horizontal section shows the origin of the tubular epiphysis caudad of the supra-commissure and also shows the plexus lying in front of the supra-commissure and presenting the appearance of a sac. In Belone (Figs. 5-6, Plate XIV) we find structures similar if not identical with those already described in the catfish. A vesicle formed from the epiphysial tube lies upon the thin plexiform roof of the third ventricle.

To sum up, then, the conditions which are found in fishes we can say that in general they are the simplest found in any of the groups. The epiphysis is usually a long, slender, tube, arising from the roof of the third ventricle immediately caudad of the supra-commissure. It is sometimes straight and sometimes curved, and extends cephalad over the roof of the diencephalon and over the pallium. In the trout and Lepidosteus numerous diverticles arise from the walls, while in a small catfish and in Belone a vesicle composed of a single layer of cells is formed at its cephalic extremity. In the eel which is remarkable in many respects we believe that the epiphysis is a glandular structure imbedded in an enormous mass of plexus. The sections however were oblique and imperfect and as the exact relations were not traceable no drawings were made.

The plexus in fishes is generally very simple in some cases being merely the thin roof of the third ventricle while in others as Lepidosteus it is intricately folded and vascular.

The amphibian brain presents many modifications in the structures forming the roof of the diencephalon.

Material. Menopoma allegheniense, Amblystoma punctatum, Salamander (species unknown), Bufo lentiginosus, Hyla versicolor, Rana halecina (Leopard frog.)

The structures present in Menopoma (Figs. 1-2, Plate XV) show a relatively far greater development of the paraphysis (plexus) than is found in fishes. The epiphysis as shown in a horizontal section takes its origin from the roof immediately caudad of the supra-commissure. It is not highly developed in any of the Amphibia and in Menopoma lies as a vesicle over the roof between the post- and supra-commissures (Fig. 1, Plate XV).

The paraphysis is not differentiated into a plicated plexus and dorsal sac as in the Reptilia, but forms a nearly solid vascular mass by the intricate foldings and plications of the entire roof of the diencephalon cephalad of the supra-commissure. A large blood sinus is seen entering the plexiform structure from the lateral ventricle.

In Amblystoma (Fig. 3, Plate XV) we find essentially the same structures as in Menopoma. The epiphysis takes the form of a vesicle, which, though not shown in the figure takes its origin from the roof caudad of the supra-commissure. The plexus is also, as in Menopoma, an intricately folded mass from which a blood vessel is seen to emerge and pierce the skull above. Eycleshymer (p. 40[1]) describes the ontogeny of the paraphysis and epiphysis in Amblystoma and speaks of a "much elongated paraphysis with lateral diverticles at its distal end arising from the posterior portion of the roof the prosencephalqn." He further states that Leydig suggested the term "anterior epiphysis" for the pararphysis. I have not had access to other sections than the one figured in Plate XV, Fig. 3, but that leads me to conclude that if diverticles, one or more, appear in the early development of Amblystoma they are transitory and should never be confounded with the epiphysial structure which is uniform throughout the vertebrates with one exception (Alligator, this paper). For further remarks on the so-called "second epiphysial outgrowth" see the discussion of the roof of the diencephalon.

Fig. 4, Plate XV, shows the connection of the epiphysial vesicle with the roof of the diencephalon also the open communication with the third ventricle. The vesicles in front are sec-

[1]The pages refer to our Historical Account, this Journal, April, 1894.

tions of diverticles from the pre-paraphysis. The velum is seen connecting the roof and base of the thalamus.

Fig. 5, Plate XV, is a perpendicular section showing the relations in the toad. The epiphysis is seen to be in communication with the roof and third ventricle. Its form is somewhat different from that described in Menopoma. Its origin too, will be seen to be immediately cephalad of the post-commissure, with a long segment separating it from the supra-commissure (See Osborn, p. 27). This position for the origin of the epiphysis I believe to be peculiar to the toad. Arising thus cephalad of the post-commissure the epiphysis runs forward to the supra-commissure where it dips down. Numerous diverticles appear from its wall throughout its length. We cannot agree with Götte (p. 16) who says that "the pineal comes to lie outside the skull cavity in the toad." At least no such evidence is furnished from our sections. We have found nothing to correspond with his "vesicle and attenuated stalk." He himself quotes Wyman, Ecker, Leydig, Rathke, and Gegenbaur as having studied the epiphysis (pineal) in batrachians and that "they all described the pineal as situated in the skull cavity, but confused the vascular plexus of the third ventricle with the pineal," which to me seems hardly possible.

Fig. 6, Plate XV, shows the conditions in the tadpole.

Fig. 7, Plate XV, is a reproduction on a larger scale of a drawing of the whole brain by C. L. Herrick (Plate XVII, Vol. III, *Jour. Comp. Neur.*). With a few modifications in form and size it would be seen to present the same structures as appear in the toad. The epiphysis with its diverticles is larger and the plexus extends dorsad and caudad over the supra-commissure and a portion of the epiphysis. The structure arising immediately in front of the supra-commissure and extending caudally over the epiphysis and post-commissure which was marked nerve, in Professor Herrick's drawing, upon closer examination appears to be connective tissue. It will thus appear that no such structures as described by De Graaf in Anura (p. 29), appear in the frog. The epiphysis does not lie excranially nor have I found any trace of an optic vesicle. His statement (p. 29) that "from the structure of the epiphysis of adults it can be determined with certainty whether a portion has been constricted off or not; in the former case it bends forward and ends in a point, in the latter it is fungiform," is an interesting one and should be kept in mind by all who are working in this most interesting field. Our drawing of Phrynosoma coronata (*Jour. Comp. Neur.*, Vol. III, Pl. XII, Figs. 1-2) would hardly agree with this statement while those of Sceloporus striatum do (Plate XVI, Fig. 5).

Fig. 8, Plate XV, is an imperfect section of the roof of the diencephalon and shows a stage in the development of the epiphysis. Although the structures are imperfect they are sufficiently intact to show that the epiphysis may assume different transitory forms in its development. In this case it seems to have a glandular structure.

If the above specimens are fair representatives of amphibians, we would say that in general the epiphysis is relatively smaller than in fishes, while the paraphysis, on the other hand, is far more complex. As to the relative position and number of the structures forming the roof of the diencephalon no variation from those of the fishes occurs.

We now come to the group most interesting in the study of the much mooted parietal eye. We are at one struck with the strange modifications of the diencephalic roof and yet recognize that even here, we have *the same parts, structures and relations* only with modified forms. In our historical resumé which preceded this article we found no exception to the reiterated statement that the epiphysis (pineal) is found in all craniate vertebrates. We propose, however, to state now after a careful examination of three different series of sections in all of which the parts of the roof were perfectly preserved, that we have found one notable exception. Figs. 1-3, Plate XVIII, are exact drawings of perpendicular and transverse sections of what is found to constitute the roof of the diencephalon in the Alligator. It is very evident from the perpendicular section (Fig. 2) that the epiphysis is entirely wanting, the post- and supra-commissures being intimately connected by an exceedingly short segment of the roof. Cephalad of the supra-commissure we have apparently two distinct evaginations of the membranous roof. Thus far we have found no special significance in this two-fold evagination. To say that we have here two anterior epiphyses and term them as such is utterly out of the question. The roof, as noted by Rabl Rückhard (p. 24), is entirely membranous. Their position in front of the supra-commissure argues that they are modifications of the diencephalic roof to form the paraphysis, and we are satisfied with such an interpretation. As to their peculiar form, with other like peculiarities in the paraphysis of reptiles we have little to say, except that they will need to be considered in connection with the mechanics of embryological development and will be further considered when we come to discuss the roof of the diencephalon. Figs. 1 and 3 are transverse sections showing the membranous plexiform roof of the thalamus. Rabl-Rückhard alone, so far as we know, has studied the roof of the diencephalon and says that "it is limited posteriorly by the post-commissure and the elongated round conarium." His next statement, that "the roof of the third ventricle is entirely membranous," is significant, and accords with his figure (Plate XIX, Fig. 7), which, though supposed to be the conarium, resembles the paraphysial projection immediately cephalad of the supra-commissure in our drawings. As the structure supposed to be the conarium by Rabl-Rückhard is shown only in a transverse section it is uncertain whether it takes its origin immediately cephalad or caudad of the supra-commissure and hence we cannot believe that what he saw was the epiphysis (conarium) in view of the relations shown in our drawings. We shall await with interest further discussions, pro or con, on the diencephalic roof of the alligator.

In all other reptiles studied the epiphysis was found to be present and the diencephalic roof to differ from from that of fishes and amphibians in that both epiphysis and paraphysis are highly developed.

In Sceloporus striatum (Fig. 5, Plate XVI) we find essentially the same structures described by us as existing in Phrynosoma coronata (*84–'93*). The epiphysis is a large vesicular structure connected to the roof of the diencephalon by means of an attenuated stalk which curves around cephalad over the the supra-commissure. This peculiar curvature might lead one to think that the epiphysis arises in front of the supra-commissure but closer inspection reveals the origin immediately caudad of it.

The nerve in Sceloporus arising from the anterior part of the supra-commissure could only be traced to the end of the epiphysis which, coming to a point, reminds one of De Graaf's statement that this proves that a vesicle has been constricted off in the embryological development (p. 29). In Phrynosoma coronata we were able to trace the nerve from its origin in the supra-commissure to a point immediately below the parietal eye. In Sceloporus the distance between the terminal points of the bones of the skull between which the parietal eye is situated is a great deal larger than that of Phrynosoma. Imbedded in the subcutaneous tissue of the skull was found the parietal eye. To this microscopic yet beautifully perfect structure reference will be made below. The paraphysis of Sceloporus is an intricately folded membrane. Two sac-like structures are found in it; one caudad of the hippocampal commissure forming the so-called *Zirbelpolster*, the other cephalad of the hippocampal commissure and extending out to the terminus of the epiphysis. Its walls lie side by side, the caudal one being slightly corrugated. Thus we find in Sceloporus a relation of the hippocampal commissure to the paraphysis which we think has heretofore remained unnoticed. We would suggest as an explanation, that in the ontogenetic development the fibres of the hippocampal commissure passing over the thin membranous roof of the diencephalon were developed before the folding of the paraphysis so that when this did occur the roof was held down at this point by the commissure and was pushed dorsad on either side. The same anomalous relation was found and figured in Phrynosoma (Vol. III, Plate XII, Fig. 1).

The Parietal Eye. Of all the degenerate organs in vertebrates there is doubtless none that has aroused such general interest among investigators as the parietal eye. Since Leydig's first study and discovery of the organ (p. 23), and De Graaf's important histological work (p. 28) giving to the organ a visual function, much time and attention has been given to its study by able authors. Among those who have written upon the parietal organ are: Spencer on Lacertilia (p. 31), McKay on Hinulia (p. 33), Beard on Ammocœtes and Petromyzon (p. 31), Klinkowström on Iguana (p. 58), Béraneck on Lacerta and Anguis (p. 60), and Studnicka on Ammocœtes and Petromzon (p. 50). Among the various functions assigned to the organ we might mention that by Rabl-Rückhard who thought it might serve as an organ of temperature sense, and that of Susanna P. Gage, who suggests that it might serve as a nutritive organ in the ontogenetic development. Most investigators, however, are now agreed that it is a degenerate visual organ. The parietal organ which we are about to describe has every appearance of a degenerated eye. It is situated in the meson, above the anterior half of the prosencephalon, within the foramen on the top of the skull, and immediately beneath the subcutaneous layer. The entire organ is surrounded by a delicate connective tissue capsule. In the figure (Plate XVII) the capsule is seen to be in connection with the surrounding tissues by connective tissue or possibly muscular strands. Within the capsule are seen the lens and retinal layers clearly differentiated. The lens is composed of columnar cells with darkly stained nuclei which are situated in the inner one half of the cells. The cells are for the most part parallel. The retina is seen to be composed of a double layer of densely pigmented cells. The sections were stained with hæmatoxylin and only the nuclei were visible. The inner layer of nuclei were more densely pigmented than the outer but were clearly made out with the twelfth inch and drawn with the camera. Close and careful study of the two layers revealed the fact that they are not two distinct layers, but are continuous. This would lead us to suggest that possibly we have here a development analogous to that found in the paired eyes, i. e. that the lens is formed from the skin and the retina, growing out from the brain as the epiphysis, is constricted off forming a primary and a secondary optic vesicle. There is a marked difference, too, between the nuclei of the lens and those of the retina, the former being oval while the latter are globular. A delicate blood sinus is shown to lie within the capsule next to the retinal layer.

Fig. 4, Plate XVI, is a drawing of the relations found and explained by C. L. Herrick in Aspidonectes spinifer (*Jour. Comp. Neur.*, Vol. I, p. 25). We have also studied the relations in Cistudo and find them to be the same as in Aspidonectes. They are however, considerably larger, the epiphysis having a larger cavity and the plexus being more intricately plicated. Fig. 5, Plate XVIII, shows the origin of the epiphysis in Chelydra. The entire roof is well described by Humphrey in the July number of this Journal. Humphrey was not sure of a communication between the cavity of the epiphysis and the third ventricle. Our sections show such an opening.

Thus far we have found the epiphysis to be either tubular or vesicular. In snakes and mammals it assumes a third form and is glandular.

Fig. 1, Plate XVI, is a perpendicnlar section of the diencephalic roof of an embryonic black snake (Bascanium constrictor). The glandular form and structure is clearly seen to be connected by an attenuated stalk to the roof of the diencephalon just caudad of the supra-commissure. The epiphysis in this stage bends caudad instead of cephalad. What the relation is in the adult we are unable to state. Cephalad of the supra-commissure we find the much folded plexiform structure, with this variation, however, that the sac-like structure forms the cephalic portion of the paraphysis instead of the caudal as is generally the case when only one sac is present.

Fig. 2, Plate XVI, is a similar section of the garter snake (Eutænia sirtalis). The glandular epiphysis is in this case globular and is imbedded in connective tissue. The section is a little torn but the relations are clearly defined. The same anomalous condition is found in the paraphysis. The epiphysis does not lie in as close proximity to the roof as in the black snake. Fig. 3, Plate XVI, is a transverse section of the epiphysis of the water snake (Tropidonotus rhombifer) and shows the same glandular structure and relations as were found in the black and garter snakes.

The glandular epiphysis of mammals is so well known and has been so thoroughly studied that nothing need be said here further than that its relation to the commissures and paraphysis corresponds to that of the lower vertebrates. Three types have been studied. Fig. 7, Plate XVIII, is a perpendicular section of Erethizon dorsatus and shows a highly developed glandular structure. Fig. 4, Plate XVIII, is a similar section of the epiphysis and associated parts of the guinea pig. Fig. 6, Plate XVIII, is a section of the epiphysis of an embryo mouse and shows its primitive relation as an evagination of the roof of the third ventricle immediately caudad of the supra-commissure.

The Roof of the Diencephalon. It is evident from the varied terminology met with in different writers, that a sufficiently comprehensive study of the roof of the diencephalon has not been made, to venture many generalizations pretending to cover the variations found in the different groups. At present about all that can be done is to call attention to the modification found in different groups by the various investigators, and suggest their probable bearing upon ones own personal research. In our work upon the vertebrates we have found the simplest relations to obtain. Three different structures, commissures, epiphysis and paraphysis, have invariably been found, and these always in the same relative positions, there being one notable exception, the alligator, where the epiphysis seems to be absent. Where modifications have been encountered they have been those of the epiphysis and paraphysis, these taking different forms in the same and in different groups.

The Epiphysis. Beginning with the fishes and running through the vertebrates we find the epiphysis to be a simple evagination of the roof of the thalamus immediately caudad of the supra-commissure. To this there is one exception, the toad, where the epiphysis arises in front of the post-commissure, there being a long segment of the roof between the supra-commissure and the epiphysis. In no case have we found two epiphyses or any hint that more than one exists. From our study of the epiphysis and the historical matter upon this subject we are of the opinion that more than one true epiphysis will never be found to exist. In favor of the argument for one epiphysis it may be well to note that not a few have been recently misled by Mr. Ritter's article and drawings of Phrynosoma, in which he regarded the epiphysis proper as a second epiphysis, and mistook the much folded plexus for the true epiphysis. See our article, The Epiphysis of Phrynosoma, etc., Jour. Comp. Neur., June, '93. For discussions of a plurality of epiphyses see Leydig, p. 41 ; His, p. 44 ; Kupffer, p. 61 ; also his recent work, the schematic cuts of which are reproduced in this paper. In general the epiphysis is tubular in fishes, vesicular in amphibians, vesicular and glandular in reptiles, and gladular in mammals. There is usually a narrow hollow stalk connecting it to the roof and diverticles are found to proceed from its walls in all types.

The paraphysis. This portion of the roof is divided into two parts by the velum transversum, and may be termed the pre- or post-paraphysis according as it lies cephalad or caudad of the velum. The post-paraphysis has been variously termed by different authors. The term "Zirbelpolster" was first applied by Edinger and not Burckhardt to whom it has occasionally been credited. The post-paraphysis assumes different forms in the various groups and varies more than the epiphysis. In fishes we find either a single layer of cells forming the roof and running over the pallium or a plexiform mass. In amphibians we find a more intricately folded mass, while in reptiles there are two distinct parts, the intricately folded mass and a sac-like evagination which lies, sometimes in close proximity to the epiphysis, giving rise to the term "Zirbelpolster," and sometimes cephalad of the folded mass, as in the black snake (Fig. 1, Plate XVI). In the mammals which we have studied the post-paraphysis is not so complex as in the lower groups. The causes for the varied forms found in the paraphysis must, we think be sought for in the mechanics of embryological growth and development, and, as already remarked, to call these sac-like projections epiphyses is absurd, as their structure and position prove their plexiform origin. From our study we would give the following scheme as covering all the forms of the roof of the diencephalon.

Post-commissure.

Epiphysis.

Supra-commisure.

Post-paraphysis { dorsal-sac. / plexus.

Velum.

Pre-paraphysis.

For schemes given by others, see Osborn, p. 27; Burckhardt, p. 42, and a short resumé of his recent work in this number; Klinkowström, p. 60; Kupffer, p. 61, and a resumé in this number of his recent work.

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ABBREVIATIONS.

ant.—hippocampal commissure.
bl. sin.—blood sinus.
cap.—capsule.
ep.—*epiph.*—epiphysis.
epith.—epithelium.
ls.—lens.
pig.—pigment.
ret. c.—retinal cells.
post. com.—post-commissure.
sup. com.—supra-commissure.

EXPLANATION OF PLATES.

PLATE XIII.

Figs. 1-2. Transverse sections of the epiphysis and related parts of *Lepidosteus.*

Figs. 3-4. Horizontal sections of the same.

Figs. 5-6. Transverse sections of the epiphysis and related parts of *Scaphirhynchus.*

Fig. 7. Perpendicular section of the epiphysis and associated parts in *Trutta fario.*

Fig. 8. Horizontal section of the epiphysis and plexus of *Scaphirhynchus.*

PLATE XIV.

Fig. 1. Horizontal section of the epiphysis of *Lophius.*

Fig. 2. Perpendicular section of the epiphysis and associated parts of the cat-fish.

Figs. 3-4. Transverse sections of the epiphysial vesicle of the cat-fish.

Figs. 5-6. Transverse sections of the epiphysis of *Belone.*

Figs. 7-8. Transverse sections of the epiphysis in *Cycleptus elongatus.*

Fig. 9. Horizontal section of the epiphysis and related parts of *Blicca.*

Figs. 10-11. Perpendicular sections of the epiphysis in *Lucioperca.*

PLATE XV.

Fig. 1. Perpendicular section of the roof of the diencephalon of *Menopoma.*

Fig. 2. Horizontal section of the epiphysis and related parts of *Menopoma.*

Figs. 3-8. Perpendicular sections of the roof of the diencephalon,—Fig. 3 of Amblystoma, Fig. 4 of a Salamander, Fig. 5 of the toad, Fig. 6 of the tadpole, Fig. 7 of the frog, Fig. 8 of a small frog.

PLATE XVI.

Figs. 1-2. Perpendicular sections of the roof of the diencephalon,—Fig. 1 of *Bascanium constrictor*, Fig. 2 of *Entænia sirtalis.*

Fig. 3. Transverse section of the epiphysis of *Tropidonotus rhombifer.*

Fig. 4. Perpendicular section of the roof of the diencephalon of *Aspidonectes spinifer.*

Fig. 5. Perendicular section of the roof of the diencephalon of *Sceloperus striatum*, showing the epiphysis, nerve, plexus, and parietal eye.

PLATE XVII.

Camera drawing of one half of the parietal eye *Sceloperus striatum* magnified twelve hundred diameters.

PLATE XVIII.

Fig. 1-3. Transverse and perpendicular sections of the roof of the diencephalon of the Alligator.

Fig. 4. Perpendicular section of the roof of the diencephalon of the Guinea pig.

Fig. 5. Horizontal section of the epiphysis of *Chelydra.*

Fig. 6. Perpendicular section of the roof of the diencephalon of a mouse embryo.

Fig. 7. Perpendicular section of the roof of the diencephalon of *Erethizon.*

CORRIGENDA.

The word "mid-brain" on p. 14, second line from the bottom, p. 15, lines 5 and 6, and p. 16, line 7 from the bottom, should be diencephalon.

THE TERMINOLOGY OF THE NERVE CELL.[1]

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The confusion resulting from the promiscuous and indiscriminate use of the various nomenclatures relating to the morphology of the brain, has also reached the deeper and more delicate structures. The recent discoveries in the histology of the central nervous system have involved to a greater or less extent the introduction of new terms and the re-arrangement of old ones. The situation at present is any thing but desirable although perhaps unavoidable. Clearness is the first law of science, and while on account of an insufficiency of words repetition may be necessary, the terms selected ought to be far enough removed from their original use to prevent any misapprehension in their new application.

Custom has long sanctioned in some instances the use of the same name for two constituents located in different parts of the same system. An example of this is found in the term "ganglion" or "ganglionic cell." The strict significance of this term should limit its use to the nerve cells found in the peripheral ganglia and not permit its indiscriminate application to the cells of the central nervous system. It is undoubtedly true that the title of the article or the connection of the text assists one in obtaining a correct understanding; but it is safer and much preferable not to rely upon the connection or dependence of ideas to make the meaning obvious when terms intrinsically correct are at hand.

Still another example might be mentioned in the use of the

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[1]Presented at the Washington, D. C., Meeting of the American Anatomists. May, 1894.

word *nucleus* referring either to the cluster of cells from which a nerve originates, or to the small area of caryoplasm situated at or near the center of one of these same cells.

The word *nidus* as used by Spitzka or *nidulus* by Herrick would be equally appropriate to this group of cells and would render much easier the path of the beginning neurologist.

The present confusion is being largely augmented by the various applications of the word *neuron*. The term is derived from the Greek and means a nerve. It has been used for some time in entomology for a nervure or a vein of an insect's wing. Lowne (1883) applied it to a portion of the eye of some invertebrates. Wilder (1884) proposed its application to the whole cerebro-spinal axis. It correlates very well with the names of the other two longitudinal body axes, *axon* and *enteron*. He has also adopted *neuraxis* from Robin (1877) in this same sense. Waldeyer (1891, Deutsch. Med. Wochenschrift) includes under *neuron* a single nerve cell with its appendages as a nerve unit. Kölliker, (1893, Handbuch der Gewebelehre des Menschen, pp. 107, 108) applies the term *neuron* to certain fiber tracts or columns of the myel, differentiating them according to their functions. Schäfer (1893) restricts its use to the axis-cylinder process alone. The latter writer has proposed a new classification of nerve cells in the light of recent investigations and bases it upon the number and kinds of processes attached to the cells. For the protoplasmic processes he employs the term *dendrons*, analogous to the German form *dendriten* (His). Nerve cells may be divided into *dendric* or *adendric*; the cells of the spinal ganglia are given as examples of the latter, but every nerve cell has an axis-cylinder process and is either *mononeuric* or *polyneuric* (dineuric, trineuric, etc.). Kölliker (1893) rejects *neuron* as standing for a nerve unit because in its original Greek meaning it stands simply for a nerve; according to this standard its use as a synonym for the cerebro-spinal axis with its entocinerea and its central canal would be inappropriate as would likewise its application to the axis-cylinder process. The same writer proposes *neurodendren* or *neurodendriten* as equivalents of *nerve unit*, but this is open to the objection that it would not be strictly applicable to cells which have no dendrons, such as are said to exist in the spinal ganglia. For the axis-cylinder process he suggests *neuraxon* or simply *axon*; but the latter term is already pre-empted having been used for ten years by Wilder as the equivalent of the longitudinal skeletal axis of the vertebrate body.

The following suggestions are offered because the matter is as yet in an unsettled condition and because however great the number and appropriateness of new terms, it will ultimately become the "survival of the fittest." For the axis-cylinder process the term *neurite* is proposed and for the other processes of the cells, retain the word *dendrites*. Except for the final syllable these are essentially the terms used by Schäfer and with their adjective endings fit without any difficulty into his scheme of classification; but the suffix *ite* relieves us of the confusion of the use of *neuron*, and furthermore in anatomy and zoology refers to that which is "part and parcel or a necessary component of any part or organ: as *sternite*, *pleurite*, *tergite*, and *podite*." From the standpoint of paronymy or the adaptation of a word into other lauguages with whatever modification of form may be necessary, *neurite* deserves recognition on an equal footing with the above examples.

Cells then may be *dendritic* or *adendritic; mononeuritic*, *dineuritic* etc., according to the number of neurites present. A confusion with any pathological term is scarcely likely to result, since the prefixes *mono* and *di* etc., would limit the meaning to this particular usage. Although two kinds of process are differentiated by the terms *dendrites* and *neurites*, the writer does not mean to imply that the *dendrites* are not nervous in function, for evidence seems to accumulate in favor of the view that their function is nervous, rather than nutritive as stated by Golgi. Besides the difference of form of these processes there is ground for believing that the functional difference lies in the probability that the *dendrites* are the collectors of the nerve impulse, as it is transmitted by contiguity from one nerve unit to another and that the *neurite* discharges the impulse that has thus been brought to the cell; or in other words that the direction of the impulse with relation to the cell is always *cellipetal* through the *dendrites* and *cellifugal* through the *neurites*. Cajal and Van Gehuchten were the first to propose this theory, but unless we recognize the peripheral branch given off from the unipolar cells of the spinal ganglia as a *dendrite*, we have an apparent exception to what has just been stated. Van Gehuchten (1893, Le Systéme nerveux de l'Homme) represents the peripheral branch from the ganglion cell much coarser than the central branch. Sclavunos has confirmed this appearance in his work on the Salamander, and the morphological distinction between these two processes is further strengthened by the fact that the peripheral process has been found to divide into two in the ganglion and continue out toward the periphery. On this basis then there are no *adendritic* cells.

It is doubtful if a classification of nerve elements adequate for all needs and conditions will ever be devised. Golgi's division of nerve cells into those of the first and second order is well known. Schäfer's classification has already been mentioned. Baker (1893, N. Y. Med. Journal) proposes the term *æsthesioblasts* to replace *ganglioblasts* used by Lenhossék, for the cells of the spinal ganglia. Such distinctions are convenient and useful and enable us to get a firmer grasp upon the various complexities of the nervous system, and to hold fast those which we already have.

For the equivalent of a nerve unit including the nerve cell with all its processes to the uttermost filament, the term *neurocyte* is suggested. It has not been possible to trace the word to its originator. It is in use in the French language and is included in the dictionary of the New Sydenham Society and Gould's New Medical Dictionary with the simple definition; a nerve cell. It correlates very well with *leucocyte* and indeed is somewhat analogous in form if we may consider the appendages of the nerve cell as comparable to the pseudopodia of a white blood corpuscle long drawn out and fixed in position. As a convenient correlative *spongiocyte* may be used for the glia or neuroglia cell. There is no inherent objection in retaining the prefix of the term applied to the embryonic cell; for in the adult there is still an analogy, more or less modified, to the earlier condition.

Each increment to the sum total of human knowledge is welcome, but it cannot be of great permanent value if clothed in terms which admit of more than one interpretation, and for this there can be no remedy but the universal employment of a clear and consistent terminology.*

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*Since the above was written I have found in the part on Nervenlehre of Dr. August Rauber's Lehrbuch der Anatomie des Menschen, Leipzig, 1894, that he uses the term *neurit* in the same sense for which *neurite* is proposed, and that in order to avoid undesirable confusion he uses the term *neura* for a nerve unit in place of Waldeyer's *neuron*. Since *neura* is the plural form of *neuron*, it is objectional because it is etymologically incorrect for a single nerve unit.

THE SEAT OF CONSCIOUSNESS.

By Dr. Paul Carus.

The late Professor Meynert considers the nervous mechanism of man as a hierarchy of three superordinated systems of projection, the highest of which terminates through the *corona radiata* in the gray cells of the hemispheres; and these hemispheres are commonly held to be the seat of consciousness. This view is at present so generally accepted that it is often repeated with the assurance of an established truth which has been verified by science beyond the least shadow of a doubt. But I make bold to say, first, that the theory stands in contradiction to several important and unequivocal facts, and secondly, that we have good reasons to regard the striate body, that great ganglion situated in the very centre of the hemispheres, as the true seat of consciousness. I shall present my arguments as concisely as possible in the hope of stimulating some specialist of the physiology of the brain either to refute or to confirm my proposition.

Consciousness is very often confounded with intelligence, and this is perhaps the main reason why many physiologists consider the hemispheres as the seat of consciousness. Consciousness, however, is very different from intelligence.

Under normal conditions, it is true, all conscious actions are simultaneously acts of intelligence; yet *vice versa* not all acts of intelligence are conscious. On the contrary, the unconscious cerebration of intelligent thought is very extensive, and there is no question about the fact that a very small part only of our intelligent thoughts is illuminated by consciousness. The experiments of the Professors Goltz, Exner, Hitzig, Munk and others, prove that only one interpretation can be made of the function of the hemispheres; they prove that the hemispheres are, as it were, store-houses of innumerable memories systematically registered according to the laws of association and psychical dynamics. Sight-impressions are conducted from the eye along the optic nerve, sounds from the ear along the acoustic nerve; in short, all the sensations start from their sense-organs and, naturally following the traces of those former impressions whose forms they fit best, pass along through an intermediate station to their various termini in the cortex. There they are fused with memories of the same kind, forming complicated brain-structures which Galton defined as composite images. In this way the various sense-impressions build up a system of composite memories, which, together with their appropriate reactions, form the frame-work of our soul.

Now, we assume all nervous activity to be sentient. The spinal cord of the frog which has been severed from the frog's brain must, so long as it properly reacts upon a stimulus, be irritable; yet the feeling that we suppose to take place in the spinal ganglion is not reported at the headquarters of the brain, for it can not be projected higher and remains unconscious. The negative part of the popular conception is perfectly correct: feelings which do not rise into the highest sphere of nervous activity cannot become conscious; but there are many nervous activities which, although they have their seat in the hemispheres, remain as much unconscious as those that take place in the lower systems of projection. Think of a piano-player. His knowledge of the notes and of the keys is registered in the acoustic centre of the hemispheres; and yet when he plays a piece that he has learned by heart a glance at the notes is sufficient to start a great number of complex and intelligent motions without engaging his consciousness. There is always a great amount of unconscious cerebration whenever we write, or read, or think. We concentrate our conscious efforts upon those points which are new and require extraordinary attention, while all those performances to which we have grown accustomed by long practice are attended to with unconscious ease. Indeed, we are constantly carried on the pinions of unconscious thought which works with machine-like accuracy and perfect reliability. The fact is, that we are much more likely to err when making conscious efforts in thinking than when we follow the unconscious routine of formerly established experiences which have grown into habits.

Now, as all this unconscious cerebration has its seat in the hemispheres, we cannot say that consciousness is constituted simply by the rising of an irritation into the highest sphere of nervous activity. Consciousness is an additional feature which sometimes does, and sometimes does not, accompany the activity of the hemispheres.

Professor Goltz's experiments, which, by the by, do not contradict the results of Hitzig's localisation theory, corroborate, as it seems to me, the fact that the hemispheres are not the seat of consciousness. Among his famous brainless animals there is a dog whose entire hemispheres have been removed, and yet he does not appear to be deprived of consciousness. He behaves, as may be expected after the excision of all systematised memories, as a perfect idiot and is, as Professor Goltz expresses it, an extremely complex reflex mechanism that eats (*eine fressende Reflex-maschine*). He walks about slowly and awkwardly, head downwards. His sense of touch over his whole skin is obtuse but not absent. He shows a lack of information concerning the surrounding world and his own body, which is mainly noticeable when he is fed. He sees like a sleep-walker who avoids obstacles without being aware of what they are. He hears, for he can be roused from his sleep by the loud noise of a fog-horn, but he hears like a man who is but half awakened from a profound sleep and before he recognises the meaning of the sound, drops back into his old stupor. The disturbances of all the other senses are analogous. He howls when hungry, but does not search for food. If fed, he eats until his stomach is full. He shows no indications of sexual instinct, and is generally without any interest or sympathy. In a word, he is, as it has been called, soul-deaf, soul-blind, and soul-dumb in all spheres of psychic life. His intelligence is a blank, but he shows all the symptoms of consciousness, for he becomes aware of sense-impressions when made upon him with sufficient vehemence, and is only incapable to refer them and interpret them as normal dogs would do with the assistance of their intelligence, which consists of the systematised memories of former sense-impressions.*

If the hemispheres are not the seat of consciousness, if they can and do perform work that is unconscious, and if sensations can be illumined by a state of awareness without the assistance of the hemispheres, if they can be perceived, as is the case with all lower animals, such as fish, whose hemispheres are small or only incipient, and as we could observe in Professor Goltz's brainless dog, where then is the seat of consciousness?

Before we answer this question let us first consider the nature of consciousness.

Anyone who wishes to know what is to be understood by consciousness must be referred to his own experience; there he finds it in all its immediate and unequivocal reality. When the unsophisticated Gothamites in a merry-making were so huddled together that they were unable to distinguish their own feet, they requested a stranger who happened to pass by to assist them in their dilemma. The wag resorted to the directest method by using a cudgel, and the success was wonderful. He who felt the pain abandoned all doubt as to the ownership of the foot that was hit, and the process which took place is what we call an act of consciousness. The brain of everyone of the Gothamites contains sentient images of a number of feet, but the consciousness "these are my feet and those are the feet of my comrades" can only originate by a co-ordination of two feelings: the sight of the cudgel falling upon one of the feet is connected with the pain that is simultaneously felt. Consciousness is a feeling, but not every feeling is conscious. The spinal ganglion of the decapitated frog, as we said above, may very well be supposed to be possesesd of feeling, but it remains a local irri-

*Prof. Goltz sent the brain of his famous dog, after the creature's death to the well known authority on nervous anatomy, Dr. Ludwig Edinger of Frankfort, on the Main, Germany, whose investigation showed that very few traces only of gray substance had been left.

tation; it is not further reported to the psychical headquarters of the frog and thus we say, the frog has ceased to feel it. Every irritation which thrills through our nervous organism takes place in response to a stimulus of some kind and must be supposed to be a feeling. If the irritation be not transmitted from the lower systems of projection to a higher and the highest range of nervous activity, the feeling remains isolated and unconnected with other feelings and cannot attain consciousness. No isolated feeling be it ever so intense can be felt. In order to be felt it must stand in relation to other feelings; in order to be distinct several, or at least two, feelings must be co-ordinated, for distinction is only by contrast. The thirst of the brainless frog may be ever so parching, and we do not doubt that the dearth that takes place in his stomach is real. The various ganglions of the sympathetic nervous system feel the thirst, but their feelings remain isolated: they remain unconnected with the old memories, especially those of quenching the thirst by drinking water, for they have been removed, and thus the thirst is there, but it is not perceived; there is a feeling, but it is not felt. The co-ordination of various feelings is missing and so there is no adaptation to circumstance, and all psychical as well as all mental activity has ceased. A feeling can become conscious only by being brought into connection with that chain of states of awareness which constitutes what we sometimes call our personality, or ego, or self. Consciousness, accordingly, is a peculiarly distinct feeling, having its seat at the centre of our nervous activity. Consciousness is not merely feeling, not any state of self-awareness, but a centralized common feeling, a product of co-ordinated feelings, allowing not only a comparison between various different feelings but also connecting them and rendering them clear by contradistinction.

There are some psychologists who identify feeling and consciousness. Professor Ziehen, for instance, speaks of the absurdity of speaking of unconscious feelings. He appears to accept consciousness as a fact which admits of no further investigation or analysis, and while admitting that many psychological states are concomitant with physiological conditions, he claims that some psychological states possess no physiological concomitants. Any psychologist who, with a critical sense of experimental science applies the old principle of introspection, often erroneously represented as utterly antiquated, will find that consciousness is never a simple feeling but a very complex and almost kaleidoscopic state of many feelings in co-ordination; and there are feelings—say for instance, a pain of a certain intensity—which are and remain conscious in the absence of stronger feelings, but can be dimmed or crowded out of the range of conscious perception as soon as stronger pains arise or at the appearance of some important thought strong enough to absorb our entire attention. As soon as the interest of the stronger feeling disappears the less intense feeling will rise again into the appperception of consciousness.

Consciousness being produced by a co-ordination of feelings we must expect that consciousness originates in an organ of co-ordination. It must be like a central telephone office in which all messages that require special attention are received. Anything that happens outside of this central station remains unknown to that part of ourselves which we can call our conscious personality or ego. Here we keep on file, as it were, all the most important events that were transacted at the main office, our recollections and old experiences. Here during the waking state the newest reports of sense-information come in; all of the sense-images of sight or sound, of smell or taste, of temperature or tactual resistance are living feelings which by irritating the nervous structures to which they are most akin rouse a number of old memories. This meeting of new sensations with old recollections produces that peculiar state of awareness and distinct apperception which we call consciousness.

Sleep is simply a closing of the central office where the incoming irritations meet the memories of former experiences. If we take a nap the co-ordination of feelings is reduced. In a light slumber sense-impressions are no longer perceived, others become indistinct and fail to rouse the recollections to which they properly belong. Sentiency, however, may continue. In profound sleep, even the hemispheres may remain active; we may dream unconscious dreams, which is proved by the fact that the motor regions may, as is the case in sleep-walking, perform their usual routine work. Sleep does not necessarily imply the stoppage of all work in the brain, but always that the psychical activities are no longer co-ordinated; and this lack of co-ordination renders them not unfeeling, but unconscious.

Consciousness, accordingly, is a complex state of many co-ordinated feelings, and their peculiar combination at a given time determines the nature of the reaction that will take place under given circumstances. Sense-reports of common occurrence are treated with indifference, while some weak and almost unimpressive feelings which, however, according to the knowledge stored up in the memories of the past are freighted with a significance that indicates the presence of great danger, might cause a storm of excitement and rouse all the latent energies in all the various parts of the brain.

A living body consists of a great number, indeed an infinitely great number of living beings. Every blood corpuscle is a little creature having an independent life of its own and a soul corresponding to the form and activity of its structure; for we must attribute to it a similar kind of life and sentiency as to analogous organisms, amœbas and moners,—a consideration which leads us to recognise the truth that our whole organism is glowing with life of which the ego of our consciousness knows nothing.

If feelings could be made audible what a symphony a human body would be! All notes of life, from the lowest to the highest are here harmoniously joined so that one serves the others and all of them in their grand harmony bring about a

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Fig. 1. Meynert's diagram of the nervous system. *CC*, Cortex of the hemispheres; *L*, Lenticular body; *S*, Nucleus caudatus; *T*, Thalamus; *V*, Corpora Quadrigemina; *R*, Olfactory nerve; *a*, Eye; *K*, Cerebellum; *B*, Brachium and Cerebellum; *h W*, posterior or sensory roots of spinal cord *v W*, anterior or motory roots of spinal cord; *MM*, sections of medulla, *ii*, voluntary tracts; 2–2, Involuntary tracts; 3–3, Sensory tracts; 4–4, Optic tracts; 5–5, Olfactory tracts; 6–6, Cerebellar tracts; 7–7, Commissural fibers connecting both hemispheres; 8–8, Commissural fibers interconnecting regions of the same hemsphere.

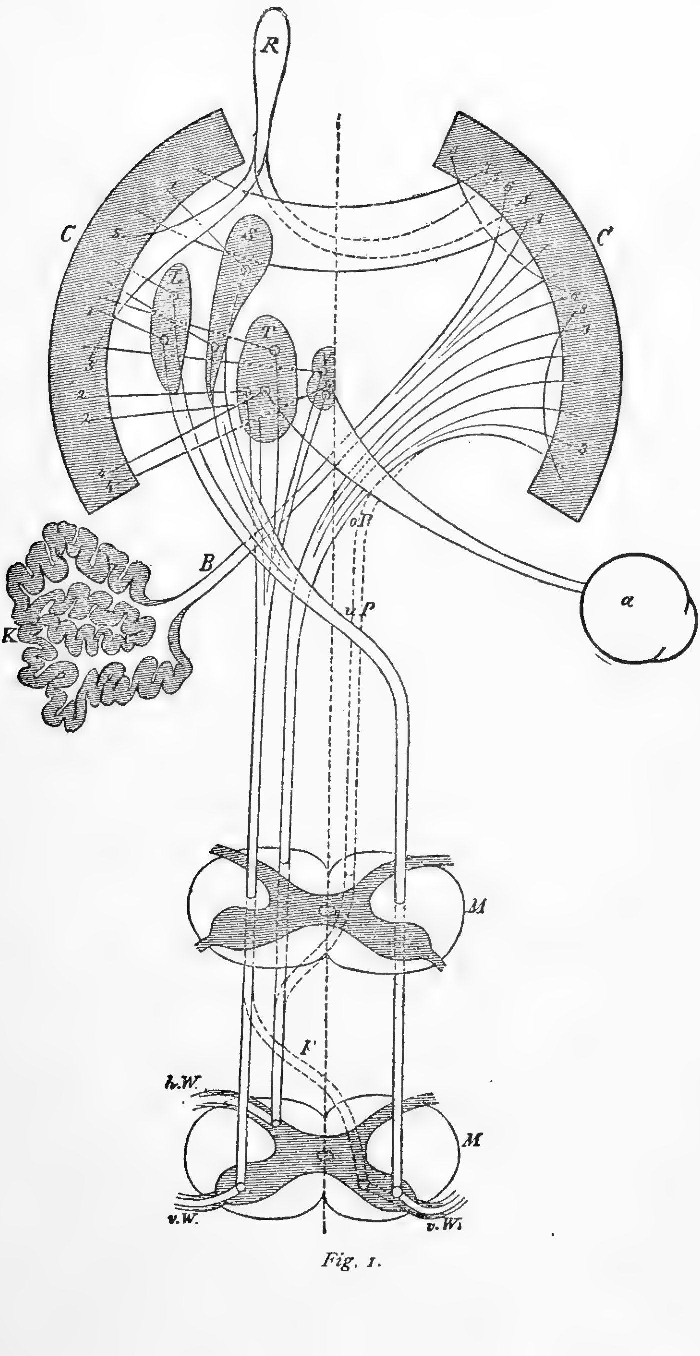


Fig. 1.

peculiar and surprisingly new effect which in one word we call the soul of man. If the various feelings that unconsciously ensoul a human organism could be seen, what a glow of light in all the rainbow colors that sentiency is capable of, in all its tints and shades, would appear before our mental eye! And their combination would produce a picture infinitely more significant than any of its parts. For their harmonious arrangement is comparable to a magic mirror which reflects the great All of which man is a part, not only as it appears in its immediate surroundings, but also in its secret order of rationality and systematic law.

The realm of consciousness is only a part of the soul of man—a small part, indeed, growing out of a large realm of dimmer feelings and sub-conscious impulses.

It appears almost a pity that only the highest top and not our whole psychical existence is illuminated by consciousness. What a grand sight would it be to be able to look down upon the living basis out of which our conscious ego develops! But we have to bear in mind that the restriction of consciousness to one spot which commands a very limited range is an imperative necessity and the indepensable condition of its proper functioning. Imagine how bewildering it would be if all the various feelings, the lowest as well as the highest, were constantly illumined by self-consciousness. Would it not be as if the President of the United States had to attend to all matters of the administration of the body politic in person? He has his hands full enough if he attends only to the most important affairs, leaving all routine work to his officials. The result of a proper psychical organisation could be attained only by a limitation of consciousness to a special sphere. Several most important centres of our nervous activity have remained almost independent, such as the regulation of the heart, the stomach, the bowels, and the lungs. They are interfered with only in extraordinary and anomalous contingencies, and even then interference from the headquarters of consciousness is not always salutary.

After this psychical excursion let us revert to the physiological structure of the nervous system. A glance at Prof. Meynert's diagram of the nervous system of man will teach you that the voluntary motions are performed by different nerves than the involuntary motions. *CC* in the diagram is the cortex, or the gray substance of the hemispheres. *L* and *S* are the lenticular body and the caudate body which both together form the striate body. *T* is the thalamus, or so-called optic couch, the great internodium of the central brain, the main function of which, as is well known, is, in spite of its name, *not* its connection with the optic nerve; *V*, the *corpora quadrigemina* or Four Hills. The voluntary motions marked *i. i.* pass through *L* or *S*, that is, either part of the striate body, the lenticular, or the caudate body, to the anterior roots whence

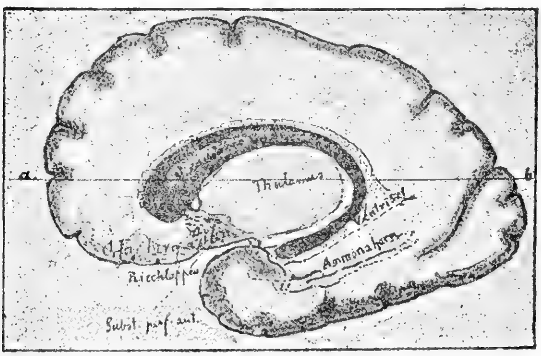


Fig. 2. (After Edinger).

the motor nerves proceed to their various muscles. The involuntary motions pass by 2. 2. through the thalamus. While the voluntary motions cross from the right to the left, and *vice versa*, the involuntary motions remain on the same side of the body. The fact that the structures of the hemispheres may perform their work in complete unconsciousness and that the tracts of voluntary motions pass through the striate body naturally suggests that the striate body is that organ in which the element of consciousness is superadded.

What is the nature of the striate body?

The striate body consists of two great ganglions, the lenticular body and the caudate body separated by the *capsula interna*, containing a great number of nervous fibres which descend from the hemispheres in the *corona radiata* and pass down to the lower centres of the nervous system. The structure of both parts of the striate body is very similar, both containing an extraordinarily great amount of gray matter, interlaced with the richest and most delicate net of capillary blood circulation, and both appearing as a continuation and a specialised part of the cortex. Fig. 2 shows the site of the caudate body in a sagittal section, after Edinger ; Fig. 3 shows a vertical section of the lenticular body, after Wernicke.

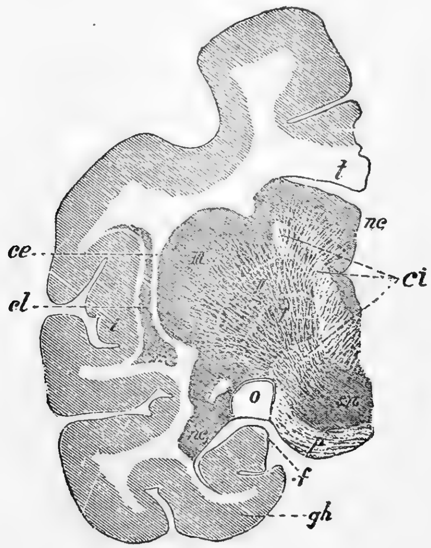


Fig. 3. (After Wernicke).

The anatomical structure of the striate body is sufficiently similar to the cortical substance to indicate that they perform an analogous function which may be the co-ordination of the cortical activity so as to serve as a focusing centre. The lenticular body consists of three stripes which gave the name to the organ. The third stripe, commonly called the shell or putamen of the lenticular body, and also the caudate body, receives a great number of fibres forming terminal stations which in many respects are similar to those in the cortical substance of the hemispheres. Thus the striate body in the putamen and the caudate body form an end-station (*ein Ursprungsgebiet*), and the whole ganglion can not be regarded as an intermediate station or internodium. It must serve some higher purpose. It must be an organ of some independent mechanism attached to and co-operating with the cerebral activity of the brain.

Ontogenetically considered the striate body is a part of the hemispheres developed by differentiation of the same gray mat-

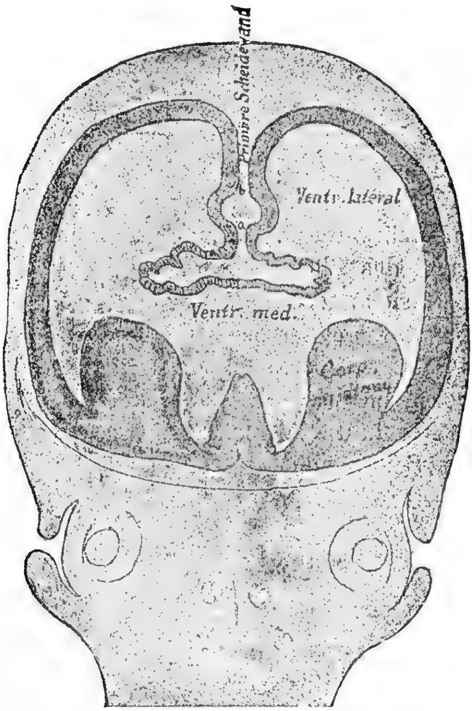


Fig. 4. (After Edinger).

ter which in a very early condition, as shows Dr. Edinger's diagram of the striped body in a fœtus of two months (Fig. 4), is continuous with the hemispheres and thus unequivocally belongs to them.* It is natural that under these conditions its connect-

*See also Dr. Edinger's sections of the brains of the fishes, reptiles and birds where the striate body appears as a mere nodus in the hemispheric region.

ions with the cortical regions bear the character of commissural fibres, *associating* its activity with various parts of the cortex, *not subordinating* them as is the case with the thalamus, which latter forms only an intermediate station (an internodium) between the higher and the lower centres. Our conception of the function of the striate body is corroborated by the fact that according to Wernicke the putamen does not stand in a direct relation to the *corona radiata*. It receives no fibres from it. Wernicke traces some fibres of the second stripe to the *corona radiata*, but even they are comparatively few. The greatest part of the two inner stripes forms an intermediate station between the putamen as well as the caudate body and the lower ganglia of the descending fibres.

Experiments show, as Landois says, that if the striate body is irritated by an electric current the result appears to be the same as if the motor centres of the hemispheres were excited all at once. Nothnagel calls the middle part of the striate body near the ventricle the *Laufknoten*, or ganglion of running.

It is a great pity that the central position of the striate body renders it very difficult to experiment with it, and thus we know little more of its functions than these isolated facts. But they seem to justify the hypothesis of considering the striate body as the ganglion of co-ordinating the various cerebral activities and rendering them voluntary by focusing their feeling in a well defined state of consciousness. It is true that, should our hypothesis be true, new problems present themselves, but that must be expected of any solution. We may ask: Is the differentiation of the striate body into the lenticular and caudate bodies only due to the fact that the fibres of the *corona radiata* happen to break their way through here, which would make the division incidental and physiologically insignificant, or does the division indicate a differentiation of function? Now the functions of consciousness are mainly two in kind: there is first the continuous apperception of self and of the surroundings; and secondly, the conscious chain of personal recollections which constitute the history of a man's life. How far do these two functions co-operate? How far are they distinct?

The former is apparently the original function, and the latter is auxiliary to the former. Must we expect each of the two functions of consciousness to be differentiated in a distinct organ? Important material, either to refute or corroborate our proposition must be expected, as we believe, not so much from experiments as from post-mortem investigations of such diseases as affect the function of consciousness and voluntary action.

Now, whether or not the striate body be the seat of consciousness we still maintain that the arguments from which we started remain true. They are:

(1) The functions of consciousness and intelligence are radically different.

(2) The great mass of cortical activity, the function of which consists in rational and intelligent reaction, performs its work automatically and in relative independence of conscious interference.

(3) A small part only of the cortical activity rises into conscious perception, where it is co-ordinated with the conscious memories of former personal experiences.

(4) There are unconscious feelings. Isolated feelings naturally remain unperceived, and consciousness is a peculiarly complex state of interrelated feelings rendering possible the self awareness of one feeling in contradistinction to other feelings.

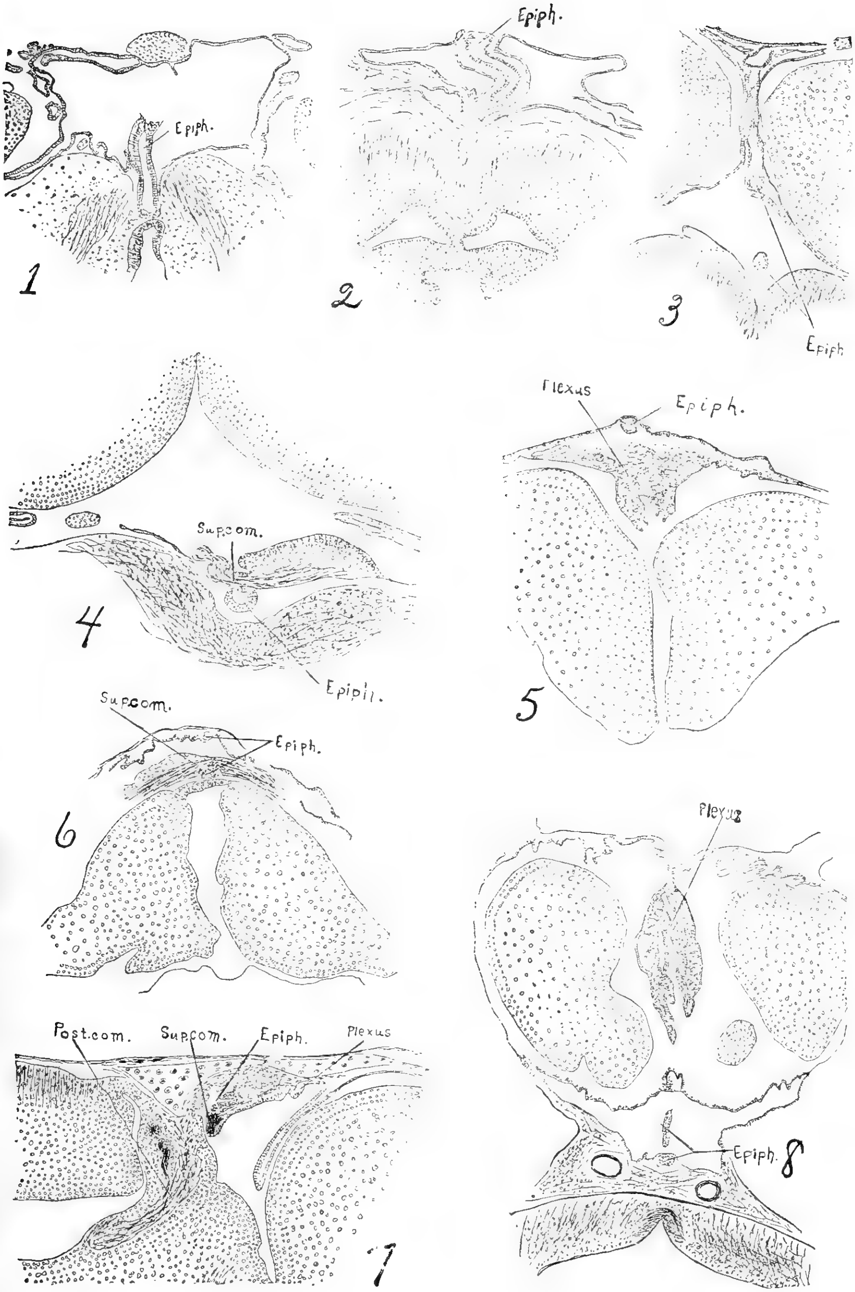
(5) Consciousness, or that range of our soul-life which we call our ego, is the product of a co-ordination of feelings.

Consciousness when extraordinarily intense and concentrated is called attention. Attention is only the concentration of thought when about to execute some special motion, and when adjusting it to peculiar and uncommon conditions. Attention is not movement but the temporary suppression of all movement in preparation for a movement of great consequence, perhaps demanding the co-operation of all the various limbs of the body. M. Ribot has excellently illustrated the conditions of this mental state in his memoir on "The Psychology of Attention." He shows how the higher and so-called artificial attention, as observable in attentive reading or study, or in the observation of scientific experiments, has gradually developed from the involuntary or natural attention, the best instance of which is an animal of prey watching for an occasion to pounce upon its victim. In a state of attention every sentiment is directed toward one point which is the object of the intended movement.

The problem may be proposed how the unity of consciousness can be attained in an organism in which all the various parts, upon a crude examination, appear to be double. In attempting to solve this problem we would say, first, that the various parts of the brain are by no means double. The center of language has its seat in the left hemisphere and is apparently unrepresented in the right hemisphere. It is most probable that each arm is represented twice in the cortical substance, once in each motory centre of the hemispheres. The right hand is best represented in the left hemisphere, and the left hand in the right hemisphere. But it appears that they are not unrepresented in either. Professor Goltz of Strasburg possesses a monkey whose left hemisphere has been removed and we should, according to the commonly accepted view, expect that she would no longer use her right hand in seizing food. Professor Goltz when showing me this monkey, called my attention to the fact that she nevertheless grasps tidbits offered her with her right hand. This seemed strange and contradictory to the localisation theory of Hitzig and Munk, but Professor Goltz explained the case by stating that the monkey after the removal of her left hemisphere actually used her left hand in preference to the right hand, but whenever she did so he gave her a slap on the left hand until she began to use her right hand. This repeated experiment produced at last a habit in her of using the right hand at once, which, according to Professor Goltz's own statement, requires a greater effort, on her part as the right hand has remained weaker than the left hand ever since the removal of the left hemisphere. This beautiful experiment of Professor Goltz does not refute Professor Hitzig's localization theory, but only corrects it by proving that the limbs of both sides are represented in both hemispheres; in the opposite stronger than in that of the same side. The same seems to be true of the centre of vision. There seems to be a complete psychical image in each hemisphere, so that the pictures of both eyes are twice projected.

The unity of consciousness may be conceived as produced by the predominance of the left striate body over the right one, but it need not be conditioned by the concentration of feelings in a single organ. The unity of consciousness is rather a unity of aim imposed upon the soul, as a product of the concentration of many feelings in one direction. We need not, therefore, as did Descartes, seek for the seat of consciousness in some organ of the body that is single. This method is too materialistic, treating consciousness as a substance, while it is not a substance but an attitude. It may have its main seat in one, or it may be present in both striate bodies, as the pictures of the eye are present in both hemispheres. The unity of the picture we see may be due to the predominance of one hemisphere over the other; it may be produced by an habitual adaptation of the focus of the weaker image to the focus of the stronger image; or the coincidence of the two focuses may in itself be sufficient to create the apperception of their identity, so that the congruence of the two main parts of the two pictures is taken as sameness. Whatever be the cause of the unity of vision, the unity of consciousness consists, in some such way as the unity of the picture we see with two eyes, in the convergence of all psychical activity in one aim and in the co-operation of many feelings toward one purpose; and it will obtain so long as a common direction attracts the attention and gives direction to the various thoughts that are aroused. Consciousness depends as little upon the uniqueness of an organ as the direction of a carriage demands the presence of only one horse. A carriage may be drawn by two or more horses, for the unity of its motion is constituted by the unity of its aim, not by the uniqueness of those powers which move it onwards; and a distraction of attention is as much possible as that a cart may be pulled by two horses in different directions. So long as the two activities of the striate bodies receive the same psychical material and perform their functions in a concerted parallelism, they may either both be seats of consciousness, or the one may predominate, receiving from the other as much assistance as one eye gives to the other; or for all we know, one may do the entire work alone, as the center of speech is unilateral while the corresponding region of the other hemisphere is differentiated for some other purpose. It is to be hoped that future experiences will throw more light on these problems.

The unity of aim arises from the practical needs of life, and originates, necessarily, through the common interest of the whole organism as a unity. Whatever the mechanism be which produces this mental convergence of many feelings in one consciousness, it is natural that it works automatically in normal brains as does the co-operative adjustment of the motions of our eyes. This, of course, does not exclude that the concentration of attention can be trained, and that our consciousness can be greatly intensified and rendered more and more lucid by education and self-control so as to reach a higher and ever higher grade of perfection.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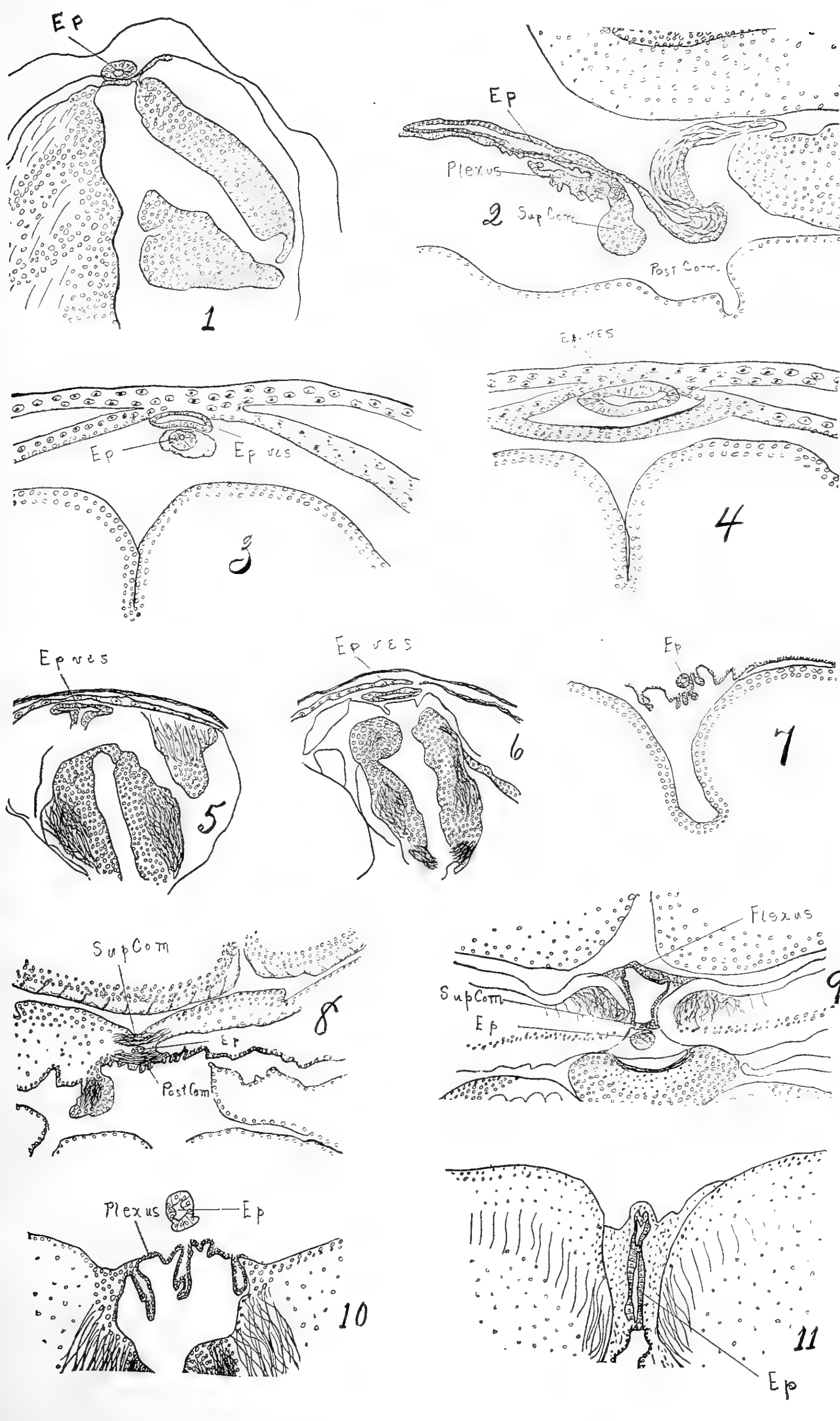
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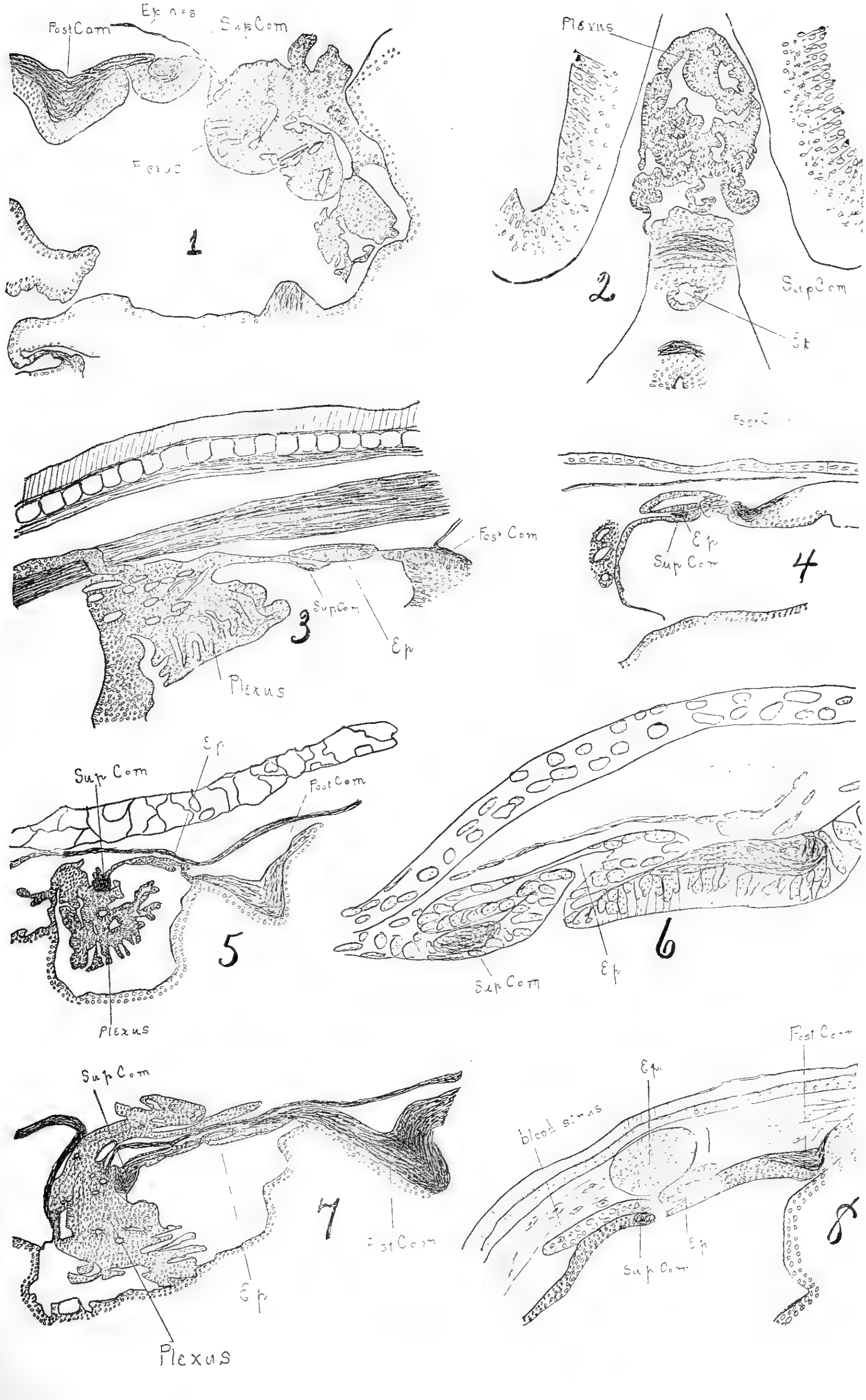
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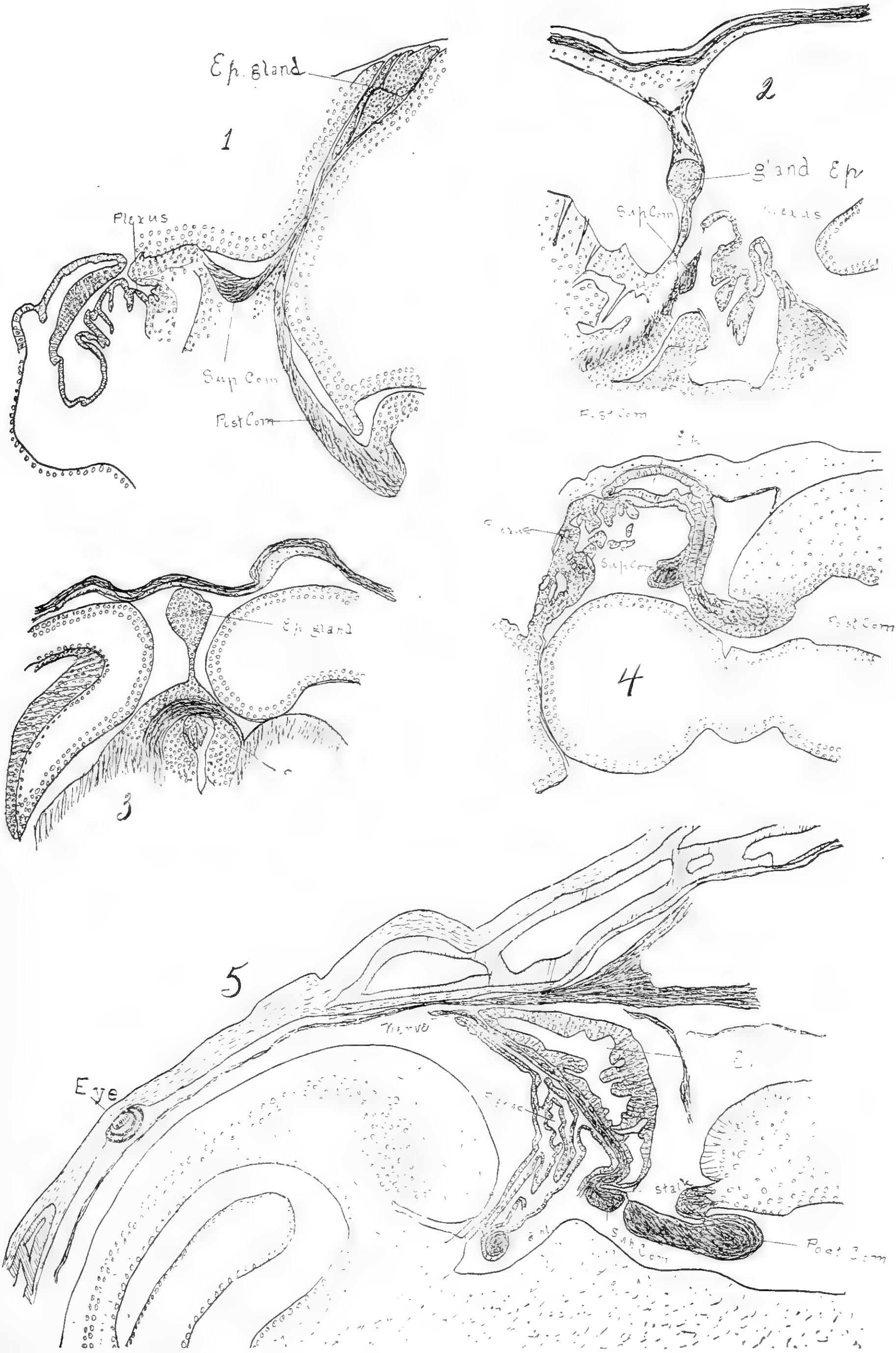
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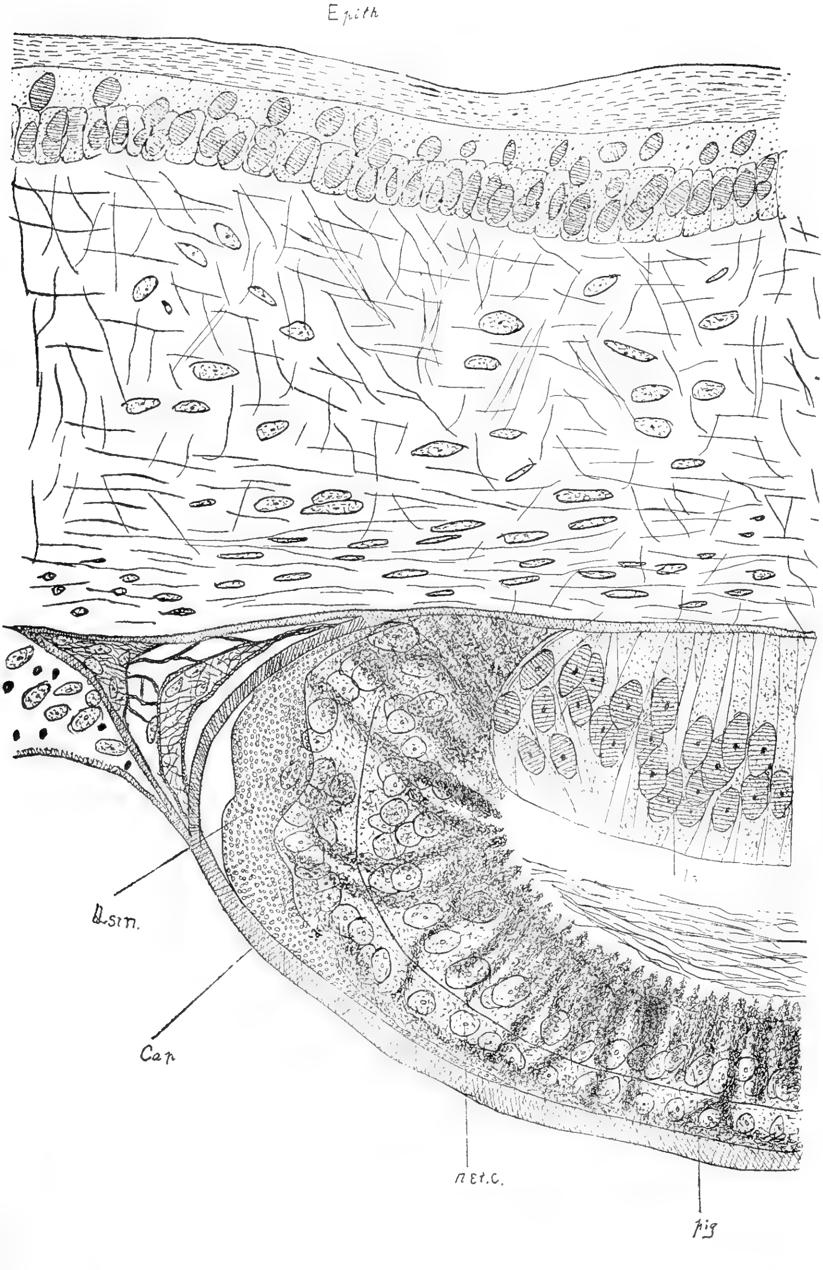
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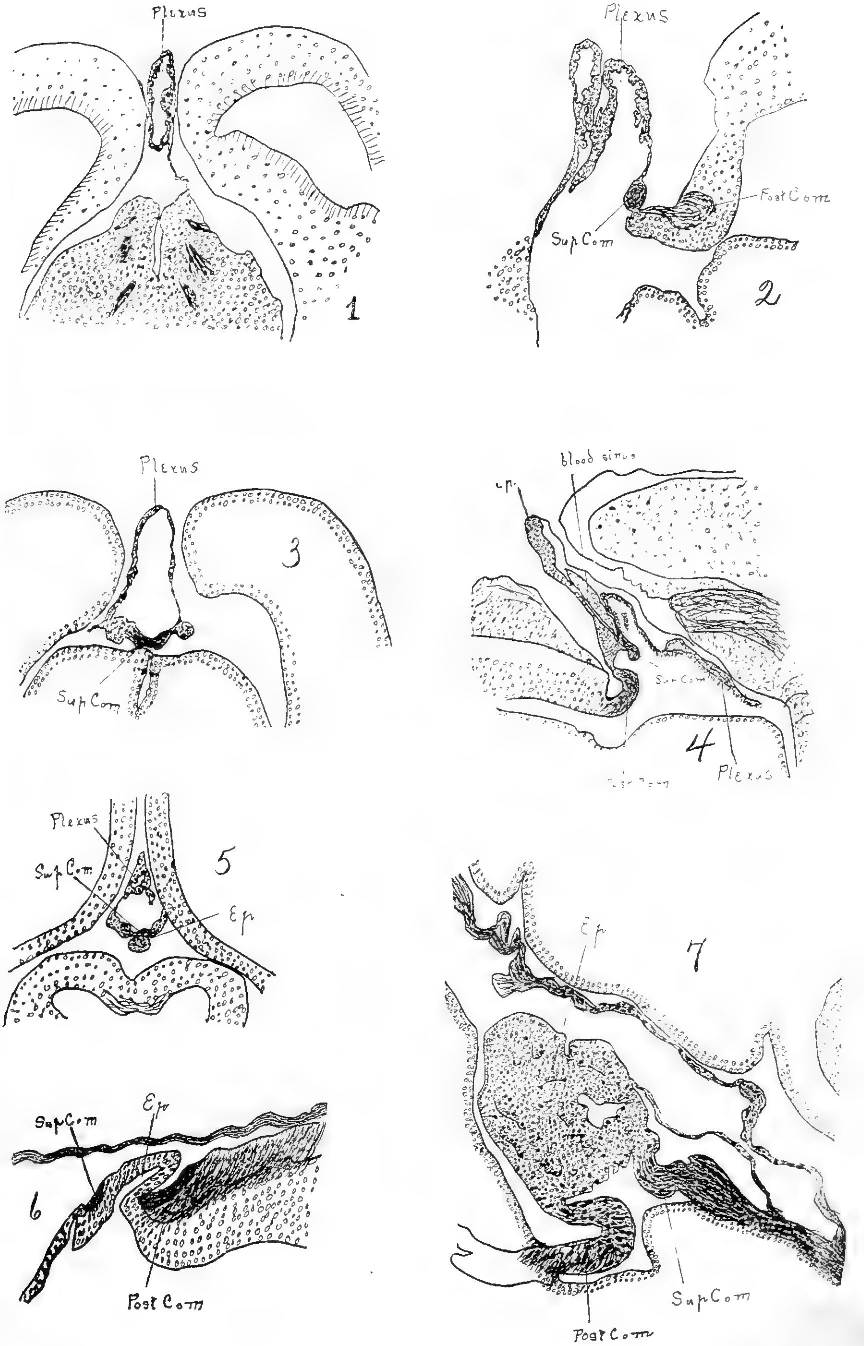
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STUDIES FROM THE NEUROLOGICAL LABORATORY OF DENISON UNIVERSITY.

XI. The Cranial Nerves of Amblystoma punctatum. With Plates XIX and XX.

By C. Judson Herrick,

Fellow in Neurology.

Within recent years both Professor Osborn [5] and Mr. Strong [8] have urged the necessity of fixing the homologies of the cranial nerves by an exact determination of both the peripheral and the central connections of the individual rami. Both of these investigators have made important additions to our knowledge of this subject and it was in the hope of adding furthur details that the present study was undertaken. The peripheral distribution of the several cranial nerves of the type chosen has been determined with considerable minuteness. Circumstances, however, having prevented the further study of the internal courses, it has seemed best to present the results already obtained in the hope that they will prove useful to others who may be working along the same lines, as well as to the students of comparative anatomy in general.

The present paper is based upon the study of two series of transections of the entire head of Amblystoma punctatum. The specimens were old larvæ 8 to 10 cm. in length, taken only a few days before the metamorphosis. The heads were fixed in chrom-acetic 24 hours, hardened in alcohol gradatim, cut consecutively (22.7 micra in thickness) after paraffine imbedding, and double stained, in the one case with aqueous hæmatoxylin and picro-carmine, in the other with aqueous hæmatoxylin and acid fuchsin in 90 per cent. alcohol. On account of the difficulty in getting good picro-carmine, the latter is the more reliable method. If the specimens are properly hardened, it serves to differentiate the various tissue systems very clearly and at the same time perfectly preserves the most minute histological details. Specimens can be cut at this age without further decalcification, though the bones of the jaws and cranium are quite strongly ossified. Older specimens require more rigorous treatment to insure decalcification. The method of study is the same as that applied by von Plessen and Rabinovicz [6] to Salamandra maculata and by G. A. Arnold [1] to Pipa americana; viz., reconstruction of the nerves by tracing them from section to section and plotting them upon cross-section paper. The degree of acuracy attainable more than compensates for the painful tedium of this process.

The surprising differences between Amblystoma and Salamandra serve to emphasize the importance of the gap in the taxonomic series which separates the two forms. How much of this difference may be due to age variation has not been determined. It should be noted that the larvæ studied by von Plessen and Rabinovicz were much younger, being from 2.5 to 3 cm. in length, while our specimens may be considered as in most respects practically adult. It is important for the final determination of the homologies that these age variations be more carefully studied than has yet been done.

The first cervical nerve (*1 sp.*) arises by four or five small ventral roots. No dorsal root was found, nor is there developed a ganglion, as in Salamandra. Immediately outside of its foramen it breaks up into a dorsal and a ventral branch. The former innervates the m. longissimus dorsi of the shoulder, the latter gives most of its fibres to the more ventral fascicles of the same muscular system. By reason of incompleteness of the series the most caudally directed fibres could not be traced to their terminus. The connections of the fibres which function as a hypoglossus could not, therefore, be discovered.

The vagus aroup. The vagus and glossopharyngeus originate together by five roots which blend in a common ganglion. Of these roots the most cephalic and dorsal one may be considered as glossopharyngeus, the others as vagus. The ganglion is triangular as viewed from above and from the candolateral angle the various rami of the vagus spring. These rami fall into four groups, three of which pass caudad and were not traced to their terminations. The fourth group contains several rami which pass directly dorsad to end in the skin.

The glossopharyngeus leaves the ganglion at the cephalo-lateral angle and immediately breaks up into three rami. One of these (5) passes laterad and caudad to the side of the neck, and gives a small twig to the skin of this region. It then dips ventrad into the first gill and turns abruptly cephalad, pursuing its course immediately beneath the first epibranchial bar. A little behind the point where this epibranchial bar passes into the cerato-branchial cartilage this nerve gives off several ramuli to the muscles of the first gill (*r. br. 1*); it then courses forward to terminate in the sensory papillæ of the dorsum of the tongue. These latter fibres constitute the *ramus lingualis.*

The second ramus of the glossopharyngeus (6) passes forward immediately under the lateral border of the otic capsule and divides into two ramuli, one passing laterally to the roof of the pharynx. the other passing farther mesad in company with a large blood-vessel lying between the otic capsule and the roof of the pharynx. It was traced forward as far as the cephalic limit of the otic capsule, where it forms an anastomosis with the ramus palatinus caudalis of the seventh nerve.

The third ramus of the glossopharyngeus (7) is the *r. communicans cum n. faciali.* In the earlier part of its course it passes near to and parallel with the ramus last described. It increases in size as it approaches the facialis and gives off one or two small branches which are directed caudad to the under surface of the m. masseter and which are probably derived from the facialis.

The acustico-facial nerve. The combined seventh and eighth nerves arise by two roots which lie in immediate contact with each other, but are quite sharply distinguishable. These roots penetrate the medulla at the same transverse level, the ventral one being considerably larger. The dorsal root (*d*) divides immediately, one moiety passing directly into the ventral root, the other passing forward to enter the Gasserian ganglion.

From the relations as presented by von Plessen and Rabinovicz in Salamandra, this would appear to be the dorsal root of the trigeminus as well, since in that species not only is this dorsal root quite distinct from the ventral, but since also its cephalic branch does not enter the Gasserian ganglion, giving rise directly to the r. frontalis and the r. maxillaris trigemini. Strong, however, regards both branches of this dorsal root in Amblystoma as facial [8, Part 2,] while Stieda [7] figures in Axolotl the whole of the facial as entering the Gasserian ganglion and seems to regard the free portion as wholly auditory. For a further discussion of these homologies consult the paragraphs devoted to the r. fronto-maxillaries trigemini.

The acustico-facial ganglion lies partly within and partly without the otic capsule. It is plainly separable into a caudal acustic and a cephalic facial portion. Neither portion is large and the ganglion cells are scattered far out on the diverging rami. Both portions pertain almost wholly to the ventral root; for, although the dorsal root contributes about half of its fibres to the cephalic ramus of the ventral root, yet these fibres have but few ganglion cells among them, most of them arching around to the ectal aspect of the ganglion, thence to enter the seventh nerve without mingling with the fibres destined to end within the otic capsule.

The ventral root divides at the ganglion into a cephalic or utricular ramus and a caudal or saccular ramus. The caudal or saccular ramus first sends a large branch directly laterad and ventrad to be distributed over the macula acustica sacculi, the *ramulus acusticus succuli* (*r. a. s*). From it there then descend the *ramulus acusticus lagenæ* (*r. a. l.*) and the *ramulus acusticus basilaris* (*r. a. b.*) to their respective papillæ. At about the same transverse level the *ramulus acusticus neglectus* (*r. a. n.*) ascends to the macula neglecta. The remaining fibres of this ramus pass back to the crista acustica posterior at the caudal extremity of the membranous ear, thus constituting the *ramulus acusticus posterior* (*r. a. p.*).

The cephalic ramus may be regarded as the combined trunks of the *ramus acusticus utriculi* and the *nervus facialis*. It enters the otic capsule by a foramen which is distinct from that of the saccular ramus, after having received, as above stated, about half of the fibres of the common dorsal root of the trigeminus and the acustico-facialis. While still within this foramen it divides into the two trunks above mentioned. The *ramus acusticus utriculi* seems to contain about half of the fibres which enter the cephalic ramus from the ventral root. It passes almost directly laterad distributing a large number of fibres to the macula utriculi by means of a very short but thick *ramulus acusticus utriculi* (*r. a. u.*) and sending two smaller branches, the *ramulus acusticus externa* (*r. a. e.*) and the *ramulus acusticus anterior* (*r. a. a.*) to the external and anterior cristæ respectively. The *ramulus ac. utriculi* is not mentioned by Arnold as occurring in Pipa, though it is described by Retzius in Rana esculenta.[1]

It will be noticed that this sharp separation of the two roots of the acustico-facialis at the ganglion, taken together with the fact that one root is distributed exclusively to the sacculus and the acustic fibres of the other exclusively to the utriculus, accords well with the morphological theories of Ayers [2] regarding the composite nature of the eighth nerve and the descent of its two rami from the ninth and seventh nerves respectively. The connection of the utricular ramus with the seventh is here sufficiently obvious. The ninth, however, originates some distance behind the eighth, and neither enters the otic capsule nor at any point comes into relations with the eighth nerve. As Professor H. W. Norris is at present engaged upon a study of the development of the ear of Amblystoma the first part of which has already been published [4], I refrain from any further comment on this interesting region.

As stated above, the *facialis* leaves its ganglion in company with the ramus acusticus utriculi. Separating from the latter, it leaves the otic capsule through several foramena, after having previously received the large branch from the dorsal root

[1]Quoted by George Haslam in his translation of Ecker's Anatomy of the Frog, p. 396.

(*d*). Near the ganglion two branches are given off, each by a distinct foramen. One of these is very small. It passes caudad, lying beneath the otic capsule and comes into communication with a branch (*6*) of the glossopharygeus. It may be described as a *ramus palatinus caudalis* (*r. p. c.*). The larger branch passes cephalad and constitutes the true *ramus palatinus* (*p*). It pursues the usual course but effects a communication with the ramus ophthalmicus trigemini (*com. p.*), instead of the usual communication with the r. maxillaris. It subsequently terminates in the roof of the mouth by a small branch only, which is continued forward after the communication.

The remainder of the facial passes directly laterad as a single trunk. At the outer edge of the otic capsule it breaks up into the following rami :

The ramus hyo-mandibularis (*hy. man.*) extends laterally through the m. depressor maxillæ inferioris and gives off some fibres to the latter (*md.*). It extends farther caudally and ventrally than any of the other rami and receives the communicating branch from the glossopharyngeus (*7*). A small twig is distributed caudad in three ramuli to innervate the skin and the mucous membrane of the pharynx of this region ; the remaining fibres pass forward to the skin and muscles underlying the cerato-hyal cartilage.

The ramus alveolaris (*al.*) dips ventrally into the lower jaw, where it passes cephalad on the mesal aspect of Meckel's cartilage in a canal lying between the latter and the articular and splenial bones. While still within the canal it sends branches to the gums and also a small branch (*c. m.*) communicating with the ramus mentalis trigemini, which occupies a corresponding position in a canal lying a little further dorsad. The ramus alveolaris leaves the bones of the jaw by a foramen on the ventro-mesal border to be distributed to the mucous membrane of the median portion of the lower lip.

The next two rami pass out together for a short distance, but almost immediately separate. The first of these passes directly out to the side of the head, over the m. depressor maxillæ inferioris, thence ventrally into the lower jaw and forward in about the same position as the ramus hyo-mandibularis, but further dorsad and laterad. It may be called—following von Plessen and Rabinovicz—the *accessory ramus hyo-mandibularis* (*h. m.*). In its peripheral distribution this ramus accords more perfectly with the hyo-mandibularis of these authors. Its identification with the accessory ramus is based upon its central relations; on the one hand it does not receive the ramus communicans from the glossopharyngeus, and on the other hand it emerges in company with the ramus buccalis. Shortly after entering the lower jaw it effects an anastomosis with the ramus mandibularis trigemini (*c. hm.*) and then continues forward to the tip of the chin in two branches lying close under the skin of the side of the face.

The ramus buccalis (*buc.*) separate farther cephalad than any of the other rami of the facialis complex. Upon separating from the last mentioned it also enters the lower jaw and passes forward along the ectal aspect of the jaw bone, between the dentary and the skin. This course it maintains up to the tip of the lower jaw, where most of its fibres are given up to the skin. Strong describes a ganglion in Amblystoma in about the proper position to correspond with the buccal ganglion of Salamandra as figured by von Plessen and Rabinovicz. Our specimens may have been older than both of the others referred to. In any case they show no trace of such a ganglion, though occasional ganglion cells are found far out in the main lateral trunk of the facial. The fibres of the ramus buccalis are mainly if not wholly derived from the dorsal root, as Strong has pointed out. The nerve which I have called the accessory hyomandibular seems to be the same as Strong's "small branch to lower jaw" which he derives from the fasciculus communis and considers the representative of the *chorda tympani* of higher forms. The anastomosis of this branch with the r. mandibularis of the fifth in Amblystoma would serve to strengthen this homology.

The various elements of the facial nerve are in this type so completely separated in their peripheral courses that their exact determination should be much easier than in the more highly specialized Anura.

Nervus abducens. The sixth nerve (*a. b. d.*) is not, as in Salamandra maculata, the smallest of the cranial nerves. It arises on the ventral surface of the medulla under the origin of the ninth by several small roots, whose combined trunk contains about 50 fibres, thus exceeding the size of the trochlearis. This trunk passes laterally and forward, lying directly beneath the main root of the trigeminus. Its subsequent course is very much as in the common frog. It enters the Gasserian ganglion, but leaves it again immediately in company with the ramus ophthalmicus trigemini. Some of the fibres uppear to pass from the entering root directly to the emerging root without entering the ganglion. Peripherally it divides into two branches, as in the frog, one for the m. rectus externus, the other for the m. retractor bulbi (*r.b.*) The ciliary branches described by Ecker for the frog were not found. Although the two branches of the sixth nerve are indistinguishably blended when they leave the Gasserian ganglion, yet it would seem that the branch destined for the m. retractor bulbi ought not to be assigned to this nerve, but to the trigeminus; for the root leaving the ganglion is nearly twice as large as the root entering it. Moreover the branch passing to the m. rectus externus is about the size of the sixth root proximally of the ganglion. The exclusion of the branch to the retractor bulbi from the abducens finds a further justification in the fact that in Salamandra maculata this muscle is not innervated from this nerve, though in that case it is the oculomotor which assumes this function.

The trigeminus differs widely from that of Salamandra maculata in many important repects. The nerve arises in two divisions, a large ventral root (*V*) and a smaller dorsal root (*d*) which serves also as the dorsal root of the facial. These roots unite to form a large Gasserian ganglion from which three rami are given off, a ramus ophthalmicus, a ramus fronto-maxillaris and a ramus mandibularis. The first of these passes directly forward from the ganglion; the other two pass directly laterad lying in immediate contact and apparently freely anastomosing for a short distance, when one turns abruptly dorsad the other ventrad.

The latter, the *ramus mandibularis* (*man.*), will first be described. It passes first through the m. pterygo-temporalis to which it sends a small branch, then between this muscle and the masseter to which it also sends a branch (*mas.*) Just before entering the lower jaw it sends forward a small branch to the skin of the angle of the mouth (*a*). Within the lower jaw it divides into two rami, one above, the other beneath Meckel's cartilage. The latter passes down through a short foramen between the dentary bone and Meckel's cartilage and then forward along with the accessory hyo-mandibularis, with which it anastomoses (*c. hm.*) It divides into two parts which subsequently anastomose and supply the skin of the lower jaw and lip. This ramus is apparently the mentalis of von Plessen and Rabinovicz, though the dorsal ramus is probably the true *ramus mentalis* (*men.*) This nerve follows the dorso-lateral border of the jaw and finally enters a canal between the dentary bone and Meckel's cartilage. While within this canal it gives off branches to the teeth and gums and divides, the smaller branch remaining in the canal, anastomosing with the ramus alveolaris of the facial (*c. m.*) and then continuing forward to the teeth and mucous lining of the lip. The larger portion of the r. mentalis then leaves the dental canal and passes forward to the skin of the lower lip.

The *ramus fronto-maxillaris* lies between the m. masseter and the m. pterygo-temporalis. It divides at once into the *r. frontalis* (*f.*) and the *r. maxillaris* (*max.*) The former takes the more medial and dorsal course, lying at first between the m. temporalis and the skin on the dorso-lateral aspect of the head. Farther forward it lies between this muscle and bulb of the eye and contributes fibres to the skin of this region and the corresponding parts as far forward as the tip of the snout. Just behind the nostril it is joined by a branch of the r. ophthalmicus (*c. f.*).

The *ramus maxillaris* separates from the r. frontalis behind the bulb of the eye and descends to the ventro-lateral border of the latter. It sends branches to the cheek behind the angle of the mouth and to the upper lip. Farther forward the main trunk lies immediately above the maxillary bone and breaks up into many fine branches behind the external nares. It is especially noteworthy that this ramus does not communicate with the r. palatinus of the facialis, as in most other vertebrates.

As noted above in connection with the origin of the seventh nerve, the ramus fronto-maxillaris in Salamandra has its own ganglion (the accessory ganglion of von Plessen and Rabinovicz) which is quite distinct from the Gasserian ganglion. It also derives its fibres from a dorsal root having the same position and the same relation to the facial as our dorsal root (*d*). Strong regards this dorsal root in Amblystoma as wholly facial. That can hardly be in the case of Salamandra for the ventral or maxillary ramus from this root effects the usual connection with the ramus palatinus. It probably therefore contains at least a large proportion of trigeminal fibres. In Amblystoma, on the other hand, we have seen that the r. maxillaris does not effect such connection with the r. palatinus and its homologies may be regarded as less definitely fixed by its peripheral relations. Yet from the comparison with Salamandra it would seem more probable that the dorsal root in Amblystoma also sends its fibres into the ramus fronto-maxillaris and that the latter should be regarded as largely, if not wholly, trigeminal. It is to be regretted that an unfortunate accident has rendered impossible the definite determination of the exact courses of these fibres through their ganglion in the specimens now under investigation. The homologies as expressed above and as indicated on the plates are therefore based mainly on peripheral distribution and may require revision as our knowledge of the central connections of the individual rami is extended.

The ramus ophthalmicus (*oph.*) is the largest of the branches of the fifth nerve. From its peripheral relations it would seem to have absorbed many fibres which are usually distributed with other rami. It passes out of the Gasserian ganglion in company with the sixth nerve and contributes some fibres to the latter for the m. retractor bulbi, as previously described. Farther forward it lies between this muscle and the m. temporalis, where it gives off a large branch whose peripheral relations are very peculiar. It first separates into two divisions. The dorsal division enters the m. rectus superior a little farther cephalad than the point where the ramus of the oculomotor nerve enters this muscle. Within the body of the muscle it divides and the two parts leave the muscle on opposite sides with undiminished volume. The smaller part is directed mesally and terminates in the skin of the dorsum. The larger part is directed laterally, penetrates the sclerotic coat of the eye-ball, and curves around to the dorsal side of the eye-ball, there to enter the ciliary process. It is therefore to be regarded as the *ciliary nerve* (*cil.*) The ventral division of the first branch of the r. ophthalmicus also separates into two ramuli which penetrate, passing mesally, the m. levator bulbi, beyond which they anastomose. In this region they establish relations with the fourth nerve (*), as described below. They subsequently break up into numerous fine branchlets to be distributed to the skin of the dorsum and upper eye lid.

Farther forward the r. ophthalmicus lies above the m. rectus internus and between the m. levator bulbi and the bulb of the eye. Here it sends another branch dorso-mesad taking about the same course as the ventral division of the branch last described, and at the cephalic end of the orbital cavity divides into three main rami. The first of these passes around to the lateral aspect of the nasal cavity and there breaks up into five branchlets which are distributed along with the terminal ramuli of the r. maxillaris to the skin of the upper lip and the region about the nostril. The second ramus passes for a short distance along the mesal aspect of the m. obliquus inferior, then passes ventrad along the mesal wall of the nasal passage to the ventro-mesal angle of the latter. Here it communicates by means of a broad commissure with the palatine nerve (*com. p.*) One of these nerves lies immediately beneath, the other immediately above the tip of the ventral lamella of the internasal plate. The commissural fibres pass around this tip and as these two nerves lie in this region only a small fraction of a millimeter apart the commissure is of course very short. The combined trunks pass forward to innervate the mucous membrane of the roof of the mouth and upper lip. The third main ramus of the ophthalmicus lies at the dorso-mesal angle of the nasal passage for the entire length of the latter. It first sends a small twig up through a foramen in the dorsal lamella of the internasal plate, which courses forward beside of the naso-lachrymal duct and finally ends in the skin above the nostril. Farther forward it sends another twig through a similar foramen which passes directly dorsad to blend with the ramus frontalis (*c.f.*), as previously described. Near the tip of the snout the remainder of this third ramus passes through another foramen and to the skin in company with the terminal filaments of the r. frontalis.

The pathetic nerve (*tr.*) is the smallest of the cranial nerves, containing at its origin only about 30 fibres. It originates at the usual point on the dorsal surface of the brain, leaves the cranium through a foramen in the parietal bone and then continues forward between this bone and the m. temporalis to the cephalic end of the latter. It then turns lat-laterally and comes into relation with the ventral division of the first branch of the ramus ophthalmicus (*). The details of this relation seem not to be constant even on opposite sides of the same animal. In the specimen figured on Plates XIX and XX these relations are as follows. Between the m. levator bulbi and the anastomosis of the dorsal and ventral ramuli of this division, the patheticus joins the dorsal ramulus, blends with it, but immediately separates again and joins the ventral division, within which it passes cephalad a short distance. Having again separated it passes directly forward to the m. obliquus superior. It is probable that in course of this plexiform union with the fifth nerve it derives a considerable number of fibres from the latter, for upon entering its muscle it contains nearly twice as many fibres as when leaving the brain. The patheticus was not found as a separate nerve, either in Salamandra or in Pipa, though it is distinct in the frog [3], in Necturus maculosus and Siren lacertina [2], and in Siredon (Axolotl) mexicanus [5 and 7.]

The oculomotor nerve (*ocm.*) innervates the usual four eyes muscles. One branch passes directly to the m. rectus superior, another to the m. rectus inferior. Another and larger branch passes to the same muscle and then divides. One half passes on the m. rectus internus and the m. obliquus inferior. The other half for the most part remains within the m. rectus inferior, though a few of the fibres pass forward beyond the muscle and spread out on the ventro-mesal aspect of the bulb of the eye. No trace of the ciliary ganglion was discovered.

In Salamandra this nerve passes to the m. rectus superior, m. rectus inferior, m. rectus internus, and m. retractor bulbi. It also communicates with the trigeminus.

The *optic nerve* (*op.*) does not exhibit a lumen, as in some amphibians, though the axial portion is crowded with deeply staining oval unipolar and bipolar nuclei.

The *olfactory nerve* (*ol.*) does not separate into well-marked dorsal and ventral branches, as in Salamandra, but breaks up into a brush of many small fibres. Terminal anastomoses with the fifth were not observed.

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DESCRIPTION OF PLATES.

REFERENCE LETTERS.

a.—Branch of r. mandibularis to angle of mouth.
abd.—Nervus abducens.
al.—Ramus alveolaris facialis.
buc.— " buccalis "
c. f.—Commissure between r. frontalis and r. ophthalmicus trigemini.
c. hm.—Commissure between the accessory r. hyo-mandibularis facialis and the r. mandibularis trigemini.
c. m.—Comminssure between the r. aveolaris facialis and the r. mentalis trigemini.
com. p.—Commissure between the r. palatinus and the r. ophthalmicus.
d.—Dorsal root of the facialis and trigeminus.
f.—Ramus frontalis trigemini.
gV.—Gasserian ganglion.
gX.—Ganglion of vagus and glossopharyngeus.
h. m.—Accessory r. hyo-mandibularis facialis.
hy. man.—Ramus hyo-mandibularis facialis.
man.—Ramus mandibularis trigemini.
mas.—Branch of r. mandibularis for m. masseter.
max.—Ramus maxillaris trigemini.
md.—Branch of r. hyo-mandibularis for m. depressor maxillæ inferioris.
men.—Ramus mentalis trigemini.
ocm.—Oculomotor nerve.
o. inf.—Branch of oculomotor to m. obliquus inferior.
op.—Optic nerve.
oph.—Ramus ophthalmicus trigemini.
ol.—Olfactory nerve.
p.—Ramus palatinus.
r. a. a.—Ramulus acusticus anterior.
r. a. b.— " " basilaris.
r. a. e.— " " exterior.
r. a. l.— " " lagenæ.
r. a. n.— " " neglecta.
r. a. p.— " " posterior.
r. a. s.— " " sacculi.
r. a. u.— " " utriculi.
r. b.—Branch from the r. ophthalmicus for m. retractor bulbi.

r. br. 1.—Branches from the glossopharyngeal to the muscles of the first branchial arch.

r. inf.—Branch of oculomotor to m. rectus inferior.

r. int.—Branch of oculomotor to m. rectus interior.

r. p. c.—Ramus palatinus caudalis.

r. s.—Branch of oculomotor to m. rectus superior.

s.—Branches of r. hyo-mandibularis for m. submaxillaris.

tr.—Trochlear (pathetic) nerve.

1, 2, 3, 4.—Rami of the vagus.

5, 6, 7.— " " glossopharyngeus.

1 sp.—First cervical nerve.

2 sp.—Second " "

*—Point of union between the fourth nerve and branches of the r. ophthalmicus.

The Roman numerals indicate the origins of the several nerves.

For convenience of reference, about the same color-scheme has been followed in the plates as that employed by von Plessen and Rabinovicz.

Olfactory nerve,	*blue.*
Optic nerve,	*green.*
Oculomotor nerve,	*orange.*
Pathetic nerve,	*black.*
Trigeminal nerve,	*red.*
Abducens nerve,	*black.*
Facial nerve,	*blue.*
Auditory nerve,	*yellow.*
Glossopharyngeal nerve,	*brown.*
Vagus nerve,	*green.*
First and second spinal nerves,	*black.*

PLATE XIX.

The cranial nerves of Amblystoma punctatum, as seen from the right side, magnified about twenty diameters.

PLATE XX.

The same as the last, seen from above.

POPULAR SCIENTIFIC BELIEFS.

Number One. Animal Magnetism.

There is a large number of beliefs which prevail to a great extent among the public but which for various reasons have no status among the recognized canons of science. In some cases these beliefs are easily explicable as the perpetuation of medieval superstitions or ecclesiastic dogma, in other cases there exists a real basis which is simply wrongly interpreted. Many of the most general and groundless beliefs are derived from hasty inductions upon inadequate observation. Thus it would seem that generations of experience would decide upon the venomous nature of a common reptile or insect but the invariable testimony of farmers, hunters and woodsmen makes the bite of the common "spreading adder" or "blowing viper" instantly fatal, while in reality it is as harmless as a toad.

The "babe of the earth" in New Mexico, which awakens terror among all classes alike, is a harmless burrowing cricket, whose pale color and "bald" head give it a fanciful human likeness.

Nowhere does credulity run to such extremes as in questions of disease and medication. The mediaeval alliance between medicine and necromancy has left us a curious inheritance of unconscious beliefs which supply the basis for the quack and the self-deceived "healer." What has largely perpetuated the tendency to seek specifics and the "laying on of hands" is the large modicum of truth which, because lying within the domain of the quack, has been denied or ignored by that which calls itself regular practice. The revelations of scientific hypnotism serve to illustrate in a way the fact that unsuspected powers are at the disposal of the charlatan which have been willfully repudiated by the profession of medicine.

The existence of a wide-spread popular belief of any kind is in itself a phenomenon worthy of study apart from the truth or falsity of the belief. Such superstitions are problems for the neurologist as well as the pathologist or physician. The neurologist inquires, what are the circumstances which predispose to such a belief, what are the phenomena on which they rest, how are these phenomena interpreted by the subject of the belief, how far is such interpretation substituted for observed fact, how far is it warranted, what are the actual forces concerned and how far are they legitimately employed in the way indicated. To the average mind the fact that a certain drug was taken at a stage of disease which soon passed away proves conclusively that the drug produced the change. If the drug is again taken at that stage and that stage then passes away nothing could shake the belief in cause and effect. It thus becomes next to impossible to secure the bare facts respecting such beliefs as relate to the cure of disease because interpretation completely obscures fact and the narrator cannot be induced to produce the latter.

It is therefore with satisfaction that we have secured the testimony of an educated and, so far as may be, unprejudiced observer as to the peculiar power which is commonly known as animal magnetism. We do not believe that it is possible for him or any one else strongly interested in a group of phenomena entirely to divest himself of the language of interpretation. It is not our purpose to undertake at this time an analysis of the phenomena as stated or to attempt to indicate how far coincidence, how far auto-suggestion, how far the counter-irritation from animal heat and how far some actual transfer of force participate. One very interesting point is the alleged transfer of a headache from patient to operator. This is distinctly insisted on and while the operator is obviously exceedingly sensitive in his nervous organism it seems hard to understand that sympathy or suggestion should have invariably produced such results. The statement that during the operation thrills pass down the operator's hands and seem to flow from them indicates a delicately adjusted vasomotor nervous mechanism peculiarly susceptable to suggestion.

The purpose of presenting this paper is to call out *facts* and *experiences* which may throw light on this perplexing subject. Mr. Cristy's paper has been abbreviated considerably and may suffer from this treatment but affords a fair view of his experience. We hope it may serve the purpose for which it was written as well as that for which it is especially germain to our pages.

[EDITOR.]

ANIMAL MAGNETISM.

BY REV. A. B. CRISTY,
Late of Albuquerque, New Mexico.

It seems strange to me that any one should doubt the fact or value of what is called animal magnetism in its application to the relief of pain, and the cure, or arrest of disease. This power and its daily use has been so constant and familiar an agent in my own life that it is a matter of surprise when men of wide experience, and of trained powers, express both ignorance and incredulity on this subject, especially when so many thousands possess the power in a pronounced degree. Surely it has been through ignorance that such are not daily using this power to soothe the weary. relieve pain, or arrest the progress of incipient disease.

In attempting to call attention to this wide-spread gift I am asked to give the simple facts which have been so often repeated in my own life as to seem only natural, as well as such unusual incidents of my own experience as have resulted in marked restoration, or arrest of disease that had been pronounced fatal by reputable physicians. In the first place, allow me to disavow any superior wisdom as to the source or true explanation of the facts or power which are set forth. The name given may not be the true one; the theories of the schools may not be applicable to my experience, but whatever may be averred about the explanation of the facts, let the record be clear as to the actual statement that such facts have occurred constantly over a period of twenty-five years in my personal life, without any attempt to name them, or to explain them in anything like a scientific manner. Permit the further statement that I am not affiliated with, nor a believer in, so-called "Christian Science."

I am not acquainted with the art, or device of mesmerism, or hypnotism, in any degree as a personal experience. I present these facts simply as an ordinary individual in private life, with no desire to avail myself of any advantage either in notoriety or in cash.

When a boy of 14 to 16 I was often called by my mother to come and put my hands on her head because she was suffering from neuralgia. I knew nothing of the reason at first, except that somehow mother forgot her suffering, and soon went to sleep, awakening free from pain. It was my habit to leave her as soon as she fell asleep, and return to my work or play. My next older sister was subject to severe sick-headaches and would also beg me to rub her head. A few minutes, not to exceed ten, would entirely relieve her, but I would receive the sick headache myself and be violently sick, and, whereas, my natural condition is constipated, and a sick headache never visited me otherwise, I would be driven at once to stool after taking her headache, and a free movement at once relieved me of all distress. Such sympathetic results never followed the treatment of any other person than this sister. But with such an experience it was not an attractive occupation for me, though my devotion to that particular sister led me again and again to afford relief when she was suffering, and this practice extended over a period of at least eight years, until I left home. As my father had possessed the same ability to soothe or remove pain, and I was at first called on only in his absence, the possession and exercise of this gift excited no remark in the family. It was a purely private matter, and so far as I thought about it at all it was not regarded as an extraordinary gift, but as simply my private affair as an individual, possessing the same, and only the same, powers as my fellows.

Nor has my subsequent knowledge or observation changed the idea, as multitudes of my acquaintance appear to be able to exert the same power that is so common in my experience.

It was a very common thing for a sore throat, or slight cough, or headache, to disappear under a few moments application of my hand.

The first experience that seemed to me remarkable, and to open my understanding to the possible expenditure of this power to serious disease, was in Nov., 1883, at Conway, Mass., where I was pastor of the Congregational church. My three children were attacked by what the physician called "capillary bronchitis."

The babe of eight months, died suddenly, and in such a manner as to give my wife a nervous shock which caused us to be greatly worried for her, and I devoted myself to her while some of the ladies of the parish attended to the other two children.

About midnight (Nov. 24) Dr. L. came to us and said that Martha, our second child 18 months old, was dying, and so, at my wife's request, I left her to go and let the child die in my arms. When the child was handed to me I was so exhausted that there was no feeling in my heart, it seemed as though all my loved ones were slipping away, and I was benumbed. So, mechanically, I took the little one and sat down, placing my left hand under the head and my right on the throat, and lay back in the chair and closed my eyes, while the doctor sat in front bending over the face to watch the last struggle. My position was purely accidental, and born of long habit by which I instinctively laid my hand on the spot where the pain was located. I had no expectation or thought of helping the child, or arresting the disease, hence I was startled in a few moments by the doctor's exclamation "Why that is a miracle, just look at the child!"

I looked and met the eyes which had been turned upwards and set, now full of animation and playfulness, and the little hands outstretched to be taken up. I was too stupid to think otherwise than that the doctor had made a mistake in his judgement, and with the question "Well she is not going to die right away is she?" I gave her to one of the ladies again, and returned to my wife.

About five o'clock the doctor came again and said "There is no mistake now Mr. C.; you must come at once, for she cannot last five minutes."

Again the child was given me, and again we assumed the same relative positions. But if I was tired and listless before, the added hours of anxious watching had not failed to rob me of all further ability to respond to the natural feelings of a father under such circumstances, and it was with an exhaustive sense of weariness that I closed my eyes and awaited the doctor's word "she is gone."

Instead, I heard the quick and startling repetition of the previous exclamation "Why this is a miracle Mr. C. What do you do to her?" "What do you mean?" I said querulously, for I felt indignant that he should twice misjudge the case. "Why," said he, "you must do something to her, for look at her, she is reviving just as she did before, and she certainly had all the appearance of one at the last point of death when you took her!" "Well," said I, "then if it is some thing I have done it must be animal magnetism, and if that has helped her I will see if she cannot be entirely relieved," and with that I sat up, summoned my energies, and concentrated my will power on the purpose to cure her. I did not move my hands from their original position, nor rub her, or make any "passes" over her; I simply forced the current of blood through my sluggish veins, and felt the increased glow of excitement in my body as of one struggling with an adversary whom he is bound to conquer. To all appearances I might have been trying to choke the child, so intense was my attitude and gaze.

For half an hour I continued thus to will my life into her and then she was too frolicsome for me to keep in that position longer, and greatly relieved, and full of the sense of a new discovery of an old fact, I returned to tell my wife and rejoice with her.

From that time I was more ready to try to relieve any, and all ailments in my family, while still refraining from attempting to help others, or even speaking of the power to do so. Since then no sore throat, or common cold, or ache, or bruise, or pain of any nature, has failed to respond to the application of my hands for a few moments. Even in the case of my own ailments, as in a sore throat, a cold, a kick from a horse which was throbbing with pain all through my left leg, the application of my hands soon quieted it, and also neuralgic pains resulting from bruises on the cheek bone yielded to my own hands.

Every member of my family has thus many times been relieved of aches, or had severe colds broken up. The child Martha when eleven years old had the scarlet fever, and at the crises was tossing with pain. I was having sole care of her. Her suffering was so evident that I asked her if there was not a place on her body that did not ache, thinking to distract her attention, and not thinking I could help her myself; after awhile she said she could think of six places "the tips of her hair, ears, teeth, fingers, toes, and roots of her hair."

Impelled by her evident distress to attempt to help her, I sat down and took hold of both wrists lightly, and in five minutes she was lying quietly and restfully, after twenty minutes I asked if she still ached. "No sir." "Not anywhere?" "No sir." "Cannot you name six places where you ache?" "No sir." I did not treat her again, but she made a very rapid recovery from the fever, and has not had any ill effects from it, as so often follow that disease.

So far as I remember, my first offer to help anyone outside of my own immediate circle was in the summer of 1891, when I was sent for in haste to baptize a babe before it died, as it was very ill from cholera infantum, and the doctor had "given it up." When I arrived I found the neighbors gathered and the mother holding the babe. They were strangers to me and did not attend my church, but their own pastor was out of town. The child was rolling its head violently, and moaning, with every appearance of speedy death, but so restless was it that I felt I could not attempt to baptize it, and instinctively offered to take it and try to quiet it.

The mother looked at me in amazement, and said it had been rolling its head nearly all day and could not be quieted. She was agitated, and without trying to argue I simply held out my hands and asked to be allowed to try. She placed the babe in my arms, and, putting my left hand under the head, I slipped the right under the clothing and rested it lightly over the bowels. The effect was at once apparent, and the group stood amazed as the child ceased to roll the head, and the expression of its eyes grew more natural. In a few minutes it was so evidently quiet that I baptized it, and handed it back to its mother. Having a church wedding that evening I could not tarry longer, and yet as soon as I could return I did so, and held the little one over an hour until it had a natural "movement" and gave it back to its mother fully quieted. I did not further treat the child, but it made a good recovery.

On Sept. 21, 1892, I was busy at a minister's meeting, when Dr. W. called me out to say that Mrs. C. a dear friend and prominent member of our church, was dying, and wanted to see me. I did not want to leave the meeting unless it was necessary, and asked if it would not do for me to go in an hour. He replied "No, I cannot be sure that she will be alive in an hour, and even half an hour from now she may be unconscious. Dr. E. and I have had a consultation and agree that she cannot last much longer, for one lung is filled and the other half, and filling rapidly." (It was a case of double pneumonia.)

I went at once, and entering the room, sat beside her and said to her, after a pause, "The Master has come and calleth for thee." Looking at me calmly she said "You could bring me no better news," and, placing her hand in mine, she asked me to sing and that her husband and daughter might come in and be with her. Taking her right hand in mine, and, without thought, clasping her wrist with my left, I sat there and sang, and prayed, as for one soon to die. As I gazed on her face I noted the purple hue of nostrils and chin, the colorless lips, and the set eyes, and also the death chill of her hand. Her breathing was in short quick gasps, distressing to the ear, and her brief effort to notice me was followed by an apparent stupor, so that I wondered if she was at all conscious of my singing.

For the full space of an hour I sat there holding her hand as described, singing, praying, or silent; and wholly unconscious of any thought of checking the disease, except the intense sympathy for a suffering friend, and for the mourning group about me.

Indeed, if any idea had flashed across my mind that I might be able to arrest the congestion in the lungs, it would have been dismissed instantly, for I had always been assured that a case of double pneumonia must necessarily prove fatal. Imagine my astonishment, then, to note that, at the end of an hour of our watching, the purplish hue had vanished from the face, the pinched look of death been replaced by the fullness of life, and the color was returned to the lips. At the same time the eyes were opened with conscious recognition, and the breathing was far less distressing. The patient also made effort to talk.

As I had important matters to attend to, and the dinner hour had arrived, I excused myself saying that she did not seem so near death as we had thought, and I would return as soon as possible. Two hours later I was on my way back to the the sick room. Fearing that death might have ensued during my absence, I stopped at the home of Dr. W. to learn if that were so, and was greeted by Mrs. W. with the exclamation "Why Mr. C., Doctor says that you have performed a miracle this morning!" "Why, how is that," said I, in perplexity. "Why, he says that you did Mrs. C. more good than all his medicine, and that the disease has made no progress since he was there with Dr. E." "Well," I replied in bewilderment, "if that is so it must be due to animal magnetism, and if she has been benefitted so far I will spend the day there and treat her intelligently."

Approaching the bedside I could not help noting the decided change in her appearance from that of the morning. She was able to talk of her affairs intelligently, and, as I still had little faith in my ability to cure her, I arranged some necessary legal business. Meanwhile I said nothing to her of the change in her condition, nor to anyone else, but as often as I could, and for as long a time as convenient, I sat down and took her hand and held it as in the morning, talking quietly, or sitting silent as seemed best. My whole will however was in the action, and I used all the methods of increasing my flow of vital force that I had any knowledge of. The difference in her breathing was the most remarkable thing, it grew so much easier and deeper; then she dozed a great deal after the business was concluded, and slept easily. Her hands became moist during the afternoon, and she appeared to be in a gentle perspiration.

So new and strange was this experience, that when I departed at supper time, although there was every evidence of a marked improvement in breathing, color, consciousnesss and general vitality, yet I had no confidence that I would see her alive in the morning.

After the evening service I sought the doctor and asked him if he thought the change was due to my power over her. "She certainly changed very markedly after your visit this morning," he said, "and the improvement has continued all the afternoon, but you cannot hope to save her, and in my opinion, it would do no good for you to go and sit up with her all night, for I do not look on this improvement as permanent. I think she will sink away suddenly again." Neither of us knew why the change had taken place, nor had we any understanding of the working of the mysterious force which had checked the disease and given new lease of life, but said that I had probably given her of my own vitality and when that was exhausted she would drop away at once.

About nine o'clock next morning I once more entered the house, and found the patient decidedly improved, the doctor had been so much impressed by the recovery as to say to those in charge "If she can improve at this rate for 48 hours she will be out of danger, for one lung seems all clear and the other no worse than the best one was yesterday morning."

I said nothing of my agency during the day but kept my place at her side as much as possible, holding the right hand simply as on the previous day. The doctor had ascribed the change to my presence and magnetism, so that the reason of my attitude was understood by those in charge. I did not rub, nor make passes, nor attempt anything of a sensational nature, simply sat there holding the hand, and talking, or singing, or thinking.

The next morning I returned to my post and was assured that if the rate of improvement was continued that day, Mrs. C. would be convalescent. By the third night I was greatly exhausted. Never in all my experience had I felt the current passing so strongly and continuously from me as during those three days. It was like the steady flow of a stream, and I was so weak when I went home that I staggered, and felt I could not go any more. But there was no need, for Mrs. C. threw off the disease rapidly, and, though confined to the bed for many weeks, she strengthened daily and ultimately arose far stronger than she had been for years.

This experience taught me that it was not necessary to place my hands at the seat of trouble, and makes me think that it is not a "nervous" force pure and simply. Since then it has been my practice to simply hold the hand and wrist, covering the pulse, and even that may not be necessary to produce the effect.

I will only mention two other cases which were outside of my family, and in fact I am no more inclined to offer my services to others than before these unconscious ministries.

Passing a home after morning service April 9th, 1893, I was called in by Mrs. L. and told that the doctor had just informed them that Nellie was dying and could not live 24 hours. It was a great shock to them, although she had been failing with consumption for months, and knew she was near her end. They wanted me to pray with them, but Nellie, (a woman of pernaps 34) was in such distress, and moaning and tossing, that she begged me to wait till she grew calmer. For half an hour I waited, and she still tossed as violently as ever, groaning with every movement.

She frequently begged my pardon for her actions, but with all her will force could not remain quiet long enough for me to receive any attention. Finally, in one of her worst spasms, she stretched out her left hand to me and exclaimed "Oh Mr. C., can't you give me some of your strength as you did Mrs. C. till I get over this distress?" I took her hand in mine saying "I can try." In less than five minutes she was lying peacefully on the pillow, and with a sigh of content said, "Oh this is blissful, thank you!"

I stayed by her some time, but had to leave for a preaching appointment at 3 P. M. As soon as I returned I went to her, and found that she had not been restless during my absence, but was so tired, and wished she might sleep. I asked if she would like to have me put her to sleep, and she said gratefully "Oh if you could." I said I would try if her mother and sister were willing for I did not know that she would ever wake again. She appealed to them, and they said they would rather she passed away in asleep than in such agony as that of the morning. So I gently passed my hands to and fro over her head, and in a few moments she was sleeping as gently as a babe.

I did not see her till the next morning, when I hardly knew her for the brightness and even gaiety with which she greeted me. I could not be with her that day, and at night she was in as great distress as the day previous, but refused to let me help her, saying that it could not be permanent, and she would have to suffer just so after it all, and she would rather die now than have this life prolonged any more. She passed away next morning.

For the past five years we have had in our home a young lady now about thirty years of age, with a slightly built, nervous, wiry frame, capable of great exertion and of tenacious vitality. I have many times relieved her of ordinary colds, and sore throats, and congested lungs, as she is susceptible to lung trouble. The first time I had occasion to attempt to help her in a serious case she had had a distressing cough for days, and the doctor had feared pneumonia, and was attending her for the trouble. She had kept us all awake for several nights by her peculiar ringing cough which was repeated so frequently as to prevent sleep for herself or anyone else.

Refusing to stay in bed, she was sitting up, and when she was not coughing, her breathing was harsh and difficult. Finally I said "I am going to try and stop that cough for you, for I can't stand it any longer." She replied that she did not think I could do her any good for the medicine had not, and she was too sick for me to help. However she lay down on the lounge and I placed my hands on her throat where she said the tickling was located. Although her cough was nearly continuous before I touched her, she did not once try to cough after I put my hand on the throat.

For an hour I kept my hands quietly in position, and she was then able to take a full long breath without a catch, and did not cough again for days, until she caught another cold, and that yielded promptly to the same treatment. All pain or sense of congestion in the lungs disappeared at the time the cough did. This experience has been repeated a dozen times with her during the past two years.

As to my methods of operation, they are very simple. I have in this narative indicated them. At first I simply obeyed the directions of my mother and let my hands rest quietly on the spot that was in pain. Then, I rubbed the parts slightly and gently, never in such a way as to produce friction. Then I learned that simply holding the wrists produced the effect, and while I treat a cold, or sore throat, or bruise locally I am not sure that it is necessary.

I am conscious that there are two distinct classes of people, those who are of the same temperament as myself, and those who are my opposites; the latter I can help. The former I seem to make nervous, or only partly help, or utterly fail to affect.

When taking the hand of any of opposite temperament I am conscious of a gentle flow of what I call, for want of a better name, "Animal Magnetism" and which I can only describe as a feeling of a current of air or the tingling of the vibration of a telegraph wire in the arm and fingers. I am so accustomed to this that in the majority of cases I am indifferent to it, and might be said to be unconscious of it. When, however, I am trying to help one, I can, by the concentration of my will power, increase the positive consciousness of the flow an hundredfold, until my arms fairly tremble with the force of the apparent current. I have found that violent exercise will also enable me to greatly increase the flow, and that by washing my hands and arms in very hot water and dashing with very cold water also quickens it. In short the power seems dependent more on the circulation than the weariness or vigor of my nervous system.

Those who have been treated by me describe the sensations differerently. My wife says the sensation is like a multitude of red hot needles flashing through her, and at times has begged me to move my hands for I was blistering her, and in one case there was the appearance of a blister behind her ear when I was treating her for neuralgia.

Others have not perceived anything, though the marked improvement in their condition was evidence that there was "something" passing from me to them. Others describe the sensation as though a gentle pricking, and still others as if a gentle current or vibration like electricity was passing. The sensation is always the same for me, no matter whom I have treated, differing only in the amount or intensity of the "current" as I call it. That this force is not peculiar to myself but exists in many others I am convinced from observation, and from the results of the experiments of others whom I have persuaded to try their powers.

That I possessed it in only a feeble degree compared with others is also clear to me from my personal acquaintance with two men who have demonstrated their powers to a truly marvelous degree. These two men are Dr. J. R. Newton once a practicing physician in Newport, R. I., who devoted the latter years of his life to the practice of magnetic cures; and Prof. John Reynolds, of Ithaca, N. Y.

THE SEAT OF CONSCIOUSNESS.

By C. L. Herrick.

I take pleasure in acknowledging the kindness of Dr. Carus who, at my request, has placed before our readers his views upon this most interesting question *in extenso*. All that Dr. Carus writes is suggestive and the little excursus into neurology is especially so. It has been suggested from several quarters that it would be profitable to indicate how the view advocated by the editor of the "Monist" stands related to the psycho-physical suggestions occasionally indicated in the "Journal." This it is the object of the present article to attempt.

First of all, questions of definition must be met. It is most unfortunate that in psychology terms have no value until their connotation is independently established. As a psychologist Dr. Carus is, of course, at liberty to coin such terms as may seem appropriate or necessary but the laity may feel agrieved to encounter familiar words with wholly unfamiliar meanings. Now in the paper before us[1] the key to the whole matter lies in the use of the word *feeling*. Our readers will doubtless be accustomed to an almost universal usage which makes of feeling an affectation or state of consciousness. Varied and conflicting as the usage has been (and one need only glance through Marshall's admirable work on pleasure-pain to discover how contradictory they are) it will be hard to find outside of Hartmann's Philosophy of the Unconscious any exception to the usage which employs feelings (whether as sensations or emotions or elements of one or other or both) as modifications of consciousness. Professor Ziehen who represents an extreme in the physiological tendency of modern psychology comments on the absurdity of speaking of unconscious feeling. But our author

[1] Journ. Comp. Neurol. IV, Sept., 1894.

opens with the thesis that all nervous action is sentient, that there are feelings evoked in the reflex processes of the brainless frog but they *are not felt!* The *spinal ganglia* even of the decapitated frog may very well be supposed to be possessed of feeling, "but it remains a local irritation; it is not reported to the psychical headquarters of the frog and thus we say the frog has ceased to feel it." Again every irritation which thrills through our nervous system takes place in response to a stimulous of some kind and must be supposed to be a feeling."

None of these in its isolated form ever attains consciousness. Consciousness is, in fact, the coordination of feelings or a product of such coordination.

We have then our fundamental definition. Feeling is not a presentation in consciousness nor is it a nervous stimulus, it is a purely nervous activity, a neurosis, the state of excitement in which a nervous element finds itself after irritation. Perhaps, however, other passages and the tendency of modern monism will permit a slight refinement upon this which seems derivable from the text of Dr. Carus' article, and we may say feeling is the sentient or psychic aspect of the neurosis. It would seem that in separating feeling from consciousness it is considered necessary to predicate consciousness in the elementary parts of a vital organism so that each cell not only has its own types of responses to stimuli but consiousness to correspond. What else is meant by the psychosis corresponding the isolated neurosis we fail to discover.

Having thus identified feeling with what to the physiologist is elementary nervous action or certain forms of such action and recognizing the inherent impossibility of affirming or denying the existence of elementary consciousness, we are prepared to follow the author to his next step. Consciousness is a product of coordinated feelings. Of course every one is prepared to admit the large amount of unconscious cerebration and to agree that only a little from the enormous mass of brain activity reaches consciousness at all. The author's use of intelligence is also peculiar and must be recognized before one ventures a criticism. Intelligence, for him, is simply the sum of stored vestiges and effects of previous cortical excitation as represented in the brain structure. The results of a college course are stored in the form of latent images and facilities for reproduction and coordination. All the experiences of a lifetime are thus implicate in the cortex. Now a new stimulus is received and the result is not so much dependent on the nature of the stimulus as the complex condition of the receptive organs. All this is intelligence, but while the coordinations are going on there is awakened, no one knows how, a consciousness of part of these results. This last act in the drama which is some how different *toto cœlo* from what precedes—a thing *sui generis*—must have a seat, an organ. Since it is a product of coordination its seat must be in an organ of coordination and such an organ is the striatum.

Now the present writer's position respecting these points is somewhat as follows:

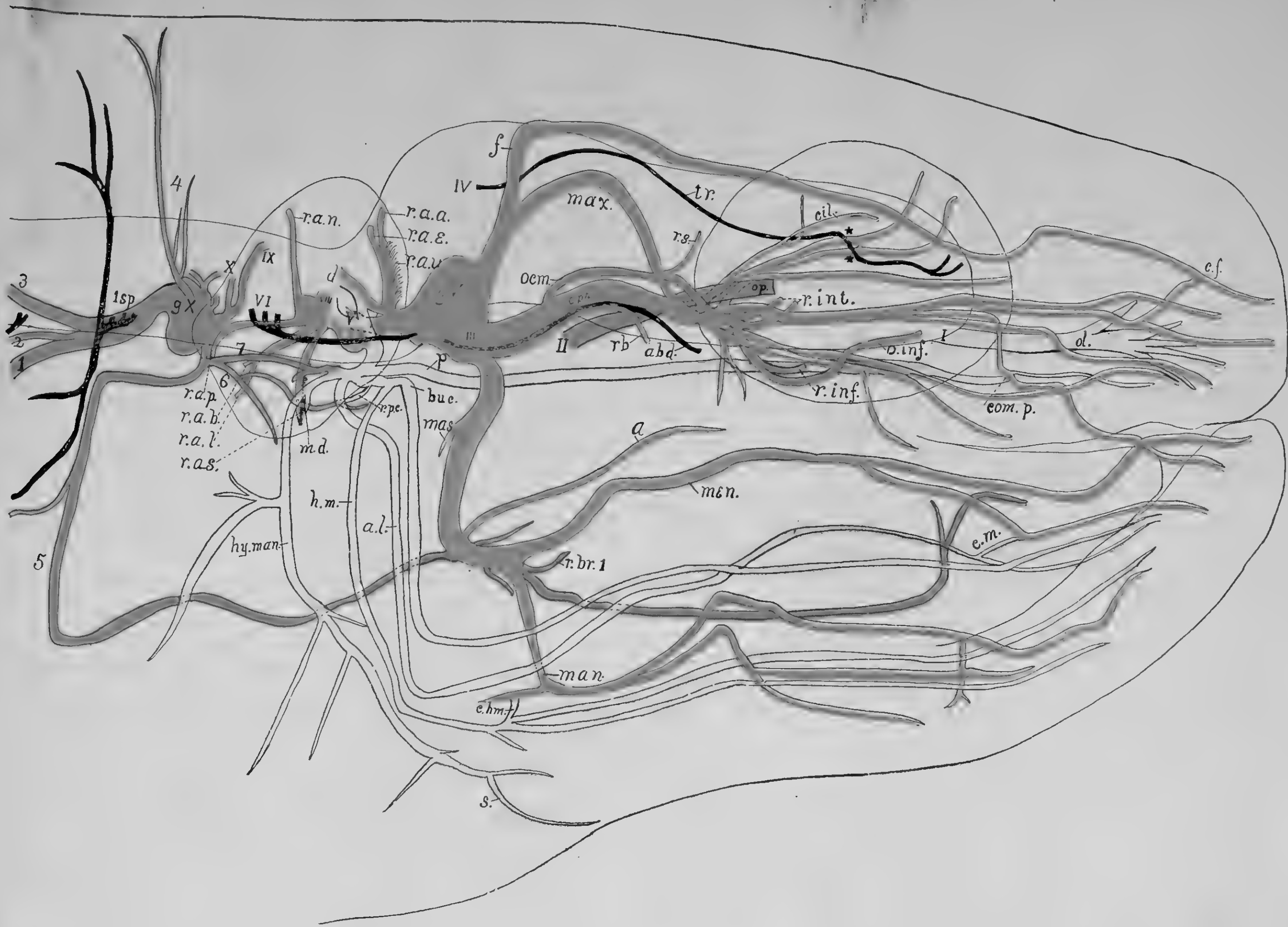
Every neurosis may have its psychosis in the sense that it registers impressions and is affected by previous states of the tissue even far back in heredity. It would be correct to speak in Dr. Carus' sense of *intelligence* of cells in the gray cornua of the cord or even in sporadic visceral ganglia (not of course of intelligence in the sense employed in the traditional psychology which connotes the idea of conscious availment of these sources of psychical activity.) Nothing like consciousness is possible under such circumstances for we believe with Dr. Carus that consciousness involves a coordination and that in a very high degree. Now when the cortex is studied by the modern methods we find in it the most complete and complex coordinating machine in the body. The silver impregnation and Weigert methods in particular reveal a richness of anastomosis and interpenetration unobserved elsewhere. On the other hand the striatum is one of the most imperfect coordinating centres in the body. We miss the interminable meshes of protoplasmic and neural dendrites which occur in the thalamus. That which has given it the spurious character of a coordinating centre is the tremendous masses of fibres passing through in various directions. The evidence of pathology may prove misleading here. It is easy to destroy the integrity of a vast number of functions by injury to the striatum but this is far from proving that these functions are coordinated there. The results of comparative and embryological research do not, it is true, so strongly differentiate the striatum from the rest of the cerebrum as would be expected from its appearance of isolation in man. In fact the striatum as such may be to all appearance absent in animals with well-developed cortex. We have offered evidence that this is originally a proliferating centre from which cortical elements are derived. It is certain at least that the anatomical discreteness of the striatum in man is no true indication of independence of function. Anyone who has studied the striatum in thin sections will I think be impressed with the paucity of elements and their apparent latent character.

As compared with the ruber or niger the striata are relatively structureless.

Thus upon the ground chosen by Dr. Carus we should not incline to recognize the striata as seats of consciousness.

However, there are other considerations which are of greater moment. Upon a dynamic theory of consciousness such as is suggested by Dr. Carus, if we correctly understand him, there is no occasion for a special organ. The fact of coordination is the fact of consciousness. If the myriads of cortical cells are so interrelated that their reactions mutually modify each other that is all that is required. No cells for the registry of the process or special devices for correlating what is already coordinated assist in any way. A physical organ for consciousness, in a certain sense, would be found in the whole neuropilem or meshwork of the cortex with the cells supplying it. If it were possible for the same sorts of interactions to be set up in the cord we see no reason for, denying consciousness to that region. However, we should be forced to go a step farther. Consciousness has a certain unity the recognition of which forces Dr. Carus and all who seek an anatomical seat of consciousness to require a solidarity of function—a simplicity in structure. This is afforded by considering the whole coordinated cortical system as a functional unit or rather conceiving the power of concerted and mutually modifying action of more or less of this continuance as the physiological basis of consciousness. Any attempt at the location of a physical centre becomes involved in absurdities. Is some one cell capable of such coordination as our concept of consciousness requires? If not, why should any number or group of cells serve this purpose better than the whole functioning and interdependent structure. The superadded coordinating complex adds nothing to the solution and we find no physiological or pathological support for the assumption. The fact that the cellular structure of the striata is obscure is no reason for assigning to it such a doubtful function.

Still again, the unity discovered by all psychologists in consciousness is not like any physiological unity we know of. It has for its peculiarity that which separates it *toto cœlo* from all physical processes in its intimate and conditioning relation to our own existence. This same peculiarity likewise removes it to a large degree from the field of possible investigation. We may push our refined analysis as far as we may but no such analysis helps us at all in our study of a fact of immediate apprehension —a state through which alone all knowledge is reached. This *felt* unity of consiousness has then no necessary relation to any *observed* physiological unity and the selection of an organ becomes a superfluity. The most we can at present say is that the highest and last thing we observe physically after an excitation of the receiving nervous mechanism is an exceedingly complex set of reactions in a system which forms the anatomical terminus of the various apparent nerve paths. The cerebral cortex is such a mechanism with a curious composition of disparate localizable "centers" with inter-communicating tracts and substituting subordinating centers. The contention for localizing is born out by facts and so is the opposite idea of a unit cortex. In fact the localization appears to be more functionally than anatomically conditioned and coordinations between the most distant regions are provided for. On the other hand, the first psychological element is a state of consciousness, a thing which is essentially dynamic—an activity, not a "state," as one often employs the word. Feeling may be employed most consistently as it seems to me as a name for such elements of consciousness as contain an explicit or implicate value to the subject; a sensation, on the other hand, is such an element lacking the subjective reference or implication. The finger resting on a rough surface affords a sensation of roughness referred to the object, but a feeling of disagreeableness or pain referred to self. Intelligence for us is the total product of the conscious activities so far as they involve recognition and construction of the cortical processes. But we have said perhaps more than enough. With what we conceive to be Dr. Carus' fundamental idea that consciousness is dynamic we are glad to agree but hesitate to accept either his terminology or the neurological suggestions embodied in the article and in his work on the soul. Nevertheless if some one should be incited to a special minute study of the striata with direct reference to the problem of cellular structure and coordination, a valuable result will have been reached.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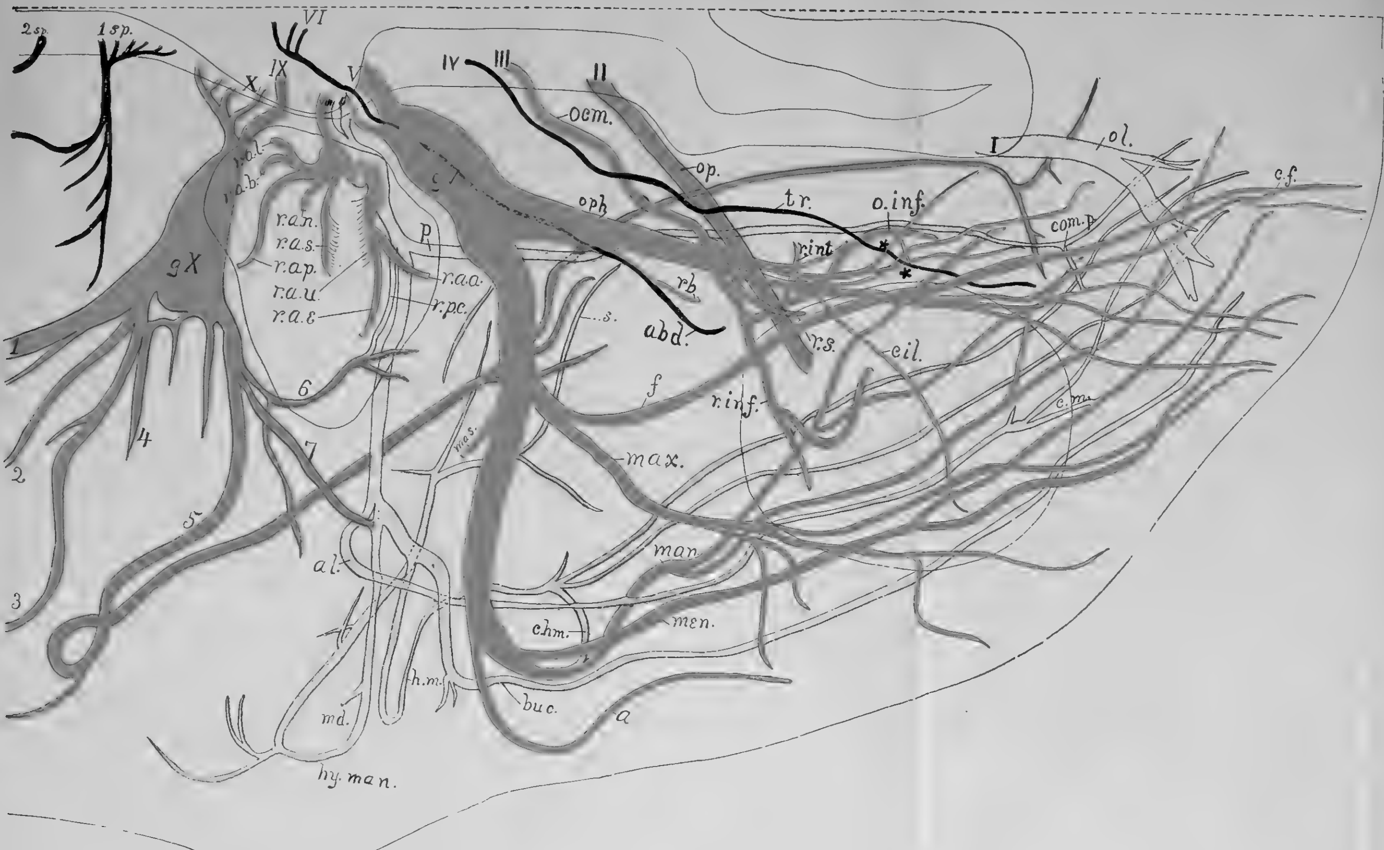
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LITERARY NOTICES.

Successful Management of Inebriety Without Secrecy in Therapeutics.[1]

By permission of the author we quote almost in full, a paper by C. H. Hughes, M. D., St. Louis.

Dr. Benjamin Rush, in his "Diseases of the Mind," published in 1812, recommends "The establishment of a hospital in every city and town in the United States for the exclusive reception of hard drinkers" and says "they are as much objects of public humanity and charity as mad people; and religious, moral and physical remedies . . . should be employed . . . for the complete and radical cure of their disease."

Since the immortal Rush rested from his labors, vast progress has been made and vaster still is making in the management of the drink habit and in the treatment of the drink disease. Facts which but a few years ago advanced observers, like Morel, Magnan and the few neurologists of their time, first took note of, touching the hereditary transmission of neuropathic instability and dipsomaniacal tendencies through ancestral alcoholic excesses and *vice versa*, have not only passed into the possession of the profession generally as practical knowledge, but have become largely the mental possessions of the people. The profession, the people, and even the unfortunate victim of the drink habit himself, have come to the understanding that habitual resistless inebriety is a disease and chiefly of the brain and nerves, and under this impression, resulting from medical research and teaching, the drunkard and the dipsomaniac now seek and the profession now give, medical relief to the sufferer, or the friends of the inebriate procure this relief for him.

The general professional consent and popular recognition of the fact that inebriety is a disease, are the results of the impressive and persistent efforts of the British and American Associations and other medical societies having in view the cure of inebriety.

[1]Read before the Section on Diseases of the Mind and Nervous System, Pan-American Medical Congress, at Washington, D. C., September 7th, 1893. Reprinted from *The Alienist and Neurologist*, Jan., 1894.

In the general recognition of the fact of the disease basis and remedial possibilities respecting this baneful, morbid vice of man's nervous system, we are hopeful of such an inestimable physical and moral fruition as must ultimately result in marked national re-invigoration, and in the postponement, at least, of national degeneracy impending through this, as one of the causes of racial decline.

We know now how to successfully scaffold and prop and steady the tottering nervous structure of an inebriate neuropath, and sustain it in fairly normal function pending its effectual reconstruction, and we know how to permanently rebuild this damaged nervous system, through the advances neurology has made during the life of the present generation of physicians, though, alas, we cannot always remove the baneful neuropathic entailments of chronic alcoholism upon the immediately succeeding generations of the drunkard, while we may and do, do much to ameliorate, modify and ward off the baneful neurotic *sequelæ*.

The unchecked degeneration of whole families through generations of neuropathic descent, such as Morel and others have presented, as the frightful admonitions of scientific research against the fatal neural and psychoneural degeneracy of alcoholic excess, are not possible under the skillful management of modern medical art as now practiced, especially in the neurological department of medical work.

It may profit us at this juncture to recur again (as mentally we often do to similar personal observation) to one of Morel's typical tables illustrative of the course of alcoholic neuropathic degeneration unassisted by our art, and I take this table from our classical and observant *confrere* across the ocean, Dr. Henry Maudsley, because the interesting researches of Morel into the formation of degenerate or morbid varieties of the human race have served to furnish to the philosophical mind of this distinguished neurophysiologist, as it has to you and me, a philosophical view of the chain of events by which alcoholism as a cause of individual degeneracy continues its morbid action through generations and finally issues, when unchecked by the arts of our profession, in extinction of the family.

First generation.—Immorality, alcoholic excess, brutal degradation.

Second generation.—Hereditary drunkenness, maniacal attacks, general paralysis.

Third generation.—Sobriety, hypochondria, Lypemania, systematic mania, homicidal tendencies.

Fourth generation.—Feeble intelligence, stupidity, first attack of mania at sixteen, transition to complete idiocy and probable extinction of family. . . .

The profession and the public believe that inebriety is a disease. They now believe it can be successfully treated and that it ought to be treated, not only for the good of the inebriate, but for the welfare of his descendants. They have now the knowledge that precedes wise action.

Drunkenness is unpopular; inebriety is on the decline; dipsomania is dangerous to the drunkard's descendants, as well as detrimental to himself.

Medicine has given to the world the substantial basis of a new reformation. It has sounded the alarm: it offers the remedy, and, on this score, we think humanity is on the road to safety.

This is one of the jewels we place in the crown of Nineteenth Century progress. We give it freely to the cause we crown without copyright, letters patent or secret process. . . .

We need not now go deeply into the pathology of chronic alcoholism, but cursorily glancing at the subject we have only to recall the findings of Virchow, Richardson, Horsley, Percy and Binz, of water decreased and fibrine changes in the blood, sometimes quite fluid, at others, coagulated, pure alcohol in the tissues, fatty globules in the circulation, fibrinous clots and excrescences in the vessels, vascular dilations, anæmia, deficient hæmoglobin, of old and excessive alcoholics.

Nor need we dwell upon other destructive and degenerative changes, which, like the annihilated phagocytes of alcoholized persons to which their well-known lack of resistance to general morbific influences is due, are secondary to the poison. We have to treat these conditions as *sequelæ*. This fact and the other prominent fact that alcohol abstracts fluid from the tissues of an organism whose very nerve cell is bathed in lymph, whose cerebro-spinal axis, as Obersteiner tells us, lies in a sea of lymph, an organism to which water is the *sine qua non* of life, give us the chart and compass of our course; and the polar star is the care and cure of the damaged brain, the brain and associate spinal and ganglionic system from whence originate the illusions, the hallucinations, delusions, anæthesias, paræsthesias, hyperæsthesias and hyperalgæsias or the peculiar polyæsthesias of these cases. All of these sensory troubles, together with the well known motor symptoms, the motor paresis, muscular tremor, twitchings and incoordination, the *paresis* of the cortical areas of the brain, where the volitions center and whence they proceed, impaired and vitiated, in the drunkard. To these and other symptoms which go to make up what Bevan Lewis designates as the motor anomalies of an alcoholic etiology and all the psychical symptomatology, which this writer and Huss and Magnan and Maudsley, Usher, Wilson and many others describe, give us adequate outline of the detail work necessary for the thorough and permanent cure of the inebriate. He will be largely made over and made whole. No three weeks' treatment will suffice. We may break him for the time of his habit in three weeks and yet leave him a wreck for life. Our duty is to repair him and make him anew if he will permit us to do it. We cannot ignore the protean nature of alcoholic symptomatology or forget the fact in our treatment of this disease that no poison except the virus of syphilis plays so extensive a *role* in the morbid affections, and degenerations of the tissues, nervous or non-nervous, as alcohol. . . .

The point of this paper is psychical assistance and neurotic support, and neurotic and organic reconstruction. We must first secure the man's safety from the thraldom of drink and repair the secondary damage later. We must first put out the fire and save what remains of the still standing structure, prop the weakened walls, and then rebuild and remove the damages. The foundation and framework of all reconstruction of the drink-damaged dipsomaniac is in the nervous system. If we can rescue that from immediate and ancestral damage, we can save the man, but we must not leave him, after our treatment, damaged and shattered in his brain or nerves or blood or vital organs. We must make him strong and resistive in the higher inhibitory volition and directing realms of the cerebral cortex and restore the normal functions within and presided over by the lower cerebro-spinal and ganglionic centers.

It is obvious that in attempting to effectually and permanently cure and reform the inebriate we undertake a large contract, one that cannot be fully complied with in the brief space of a few weeks. When we have broken the chain of morbid habit there yet devolves upon us the duty of after-care that the victim's health may not be permanently shattered, and that insanity and other evils may not follow.

The first essential to the cure of inebriety is the substitution of a less harmful support to the shattered brain, nerves and damaged vital organs, than alcohol, and I name them in their order of preference. The morphias or opium, strychnia, the quinias and cinchonas, valerianates, cocas, the ammonium bromide, etc., etc.

The second and concomitant essential is water—plenty of water or its equivalent, milk. The tissues must have water, the blood must have it, the emunctories and the skin must have it.

The third and concomitant essential is rest. Normal nature tired prescribes it for every bodily or mental overtax. Exhausted abnormal nature always needs it and demands it often. The machinery of the the human organism in all its parts—psychical or physical—must be put at rest for the best repair.

The chief essential for rest is a new and proper environment, and subsidiary to this are the chemical restraints therapeutics may place on over-acting cells: chloral, sulphonal, the bromides, the vegetable narcotics, old and new, the valerianates, the opiates, cephalic galvanization, and soothing music and the bath.

The fourth essential is the removal of the *debris* of the last and previous drunks and of the interim of organic torpidity and depressed vitality. The scavenger cells, diminished in number or absent as they are *in toto* from the blood, and the emunctories have failed in their physiologically appointed work; the congested brain, liver, stomach, intestinal tract, mucous membranes generally, torpid liver, bowels and skin, are to be relieved and set at their proper work again.

Here, water, saline laxative water without stint, is the remedy *par excellence*. It flushes the intestinal tract and the excreting organs. Nature suggests it first of all after the rest she enforces after a prostrating spree.

I need not here dwell on the proper therapeutic blendings for this hydrotherapy to give more special direction to liver, kidneys, skin or bowels.

My preference is for an effervescent saline that clears out the alimentary tract and tranquillizes the brain and nerves at the same time (though mercurials are often not amiss), and then to properly start all the pumps of the system that may not be acting well and maintain them in moderate activity till there remains no pathological clogging of the wheels of physiological activity, but I do not approve of over-active catharsis. Moderation and not violence in this regard is my motto.

The fifth and concomitant essential is reconstruction of the undoubtedly damaged cerebro-spinal centers and the several affected organs of vegetative life. A drunkard is more or less damaged in many parts of his anatomy at the same time. He comes more nearly to being affected all over in spots than most patients we have to treat.

We begin reconstruction with the beginning of treatment. It begins with rest and sleep and food and change of surroundings, when

Nature, without further aid, can effect it, rest, nutrition and phosphates, the hypophosphites and the reconstructive hæmatics and other rebuilders of the blood. Milk, beef-tea and capsicum and other stomachics. Early in the treatment a hair of the dog that bit him—a milk-punch or egg-nog, egg phosphates flavored with wine or whiskey, the latter soon withdrawn. In this stage the wines of coca, the beef, wine, iron and strychnine compounds, calisaya cordials, egg phosphates and stimulant tonics, are temporarily admissible.

When the patient is cured of his recent attack of delirium tremens, or recuperated from his last debauch then the hypodermic medication that is to hold him from further relapse, to re-tone his system and break him of his taste, must be instituted, if we have not begun it sooner.

The sixth and final essential, to which all our previous efforts lead us, is destruction of the drink craving, and this is done on physiological principles. The drink craving is pathological perversion of physiological cell action, and lies in the realm of the cerebral cortex. This part of our subject belongs to psychiatry and psychical suggestion, effected by a therapy directed to these morbidly acting centers of the brain, accomplishes our purpose. When the drink craving comes on, having in the meantime rebuilt the shattered brain and nervous system and restored the mental tone as much as possible, we do not absolutely inhibit the use of the accustomed drink, but train the victim's own inhibitions, first, by suggestion; second, by moderate indulgence properly treated.

We do not say, "You shall not, but you had better not drink. You know it is poison to you and you are its slave. You should resist. Your treatment has made you strong. You *can* resist. Whiskey no longer tastes as good to you. You no longer need it. You have the power now and should assert your manhood," and with these suggestions, perhaps the victim will try the liquor, we give him *spiritus frumenti* f oz. ij, *cum vini antimonii*, f dr. i, and repeat *ad libitum*, or we have previously given him apomorphia with aurum bichloride for psychical effect.

Under this or similar management of the appetite, the victim acquires a disgust for his favorite drink, he discovers his inhibition of the propensity is strengthened, and a disgust supplants the taste, which abides till he is fully restored in nerve tone and power to permanently resist and assert his manhood and maintain it against all future assaults of the foe.

As I cannot, in the brief time allowed, further detail my plan of treatment, this outline must suffice, with the promise in another communication of special prescriptions and combinations, embodying the plan of treatment here outlined, and which has proven successful in desperate cases.

After your patient is cured, after the toxic effects of alcohol have gone from the blood, and the higher and lower nerve centers and the damaged tissues of the body have regained their normal nutrition, powers of assimilation, and strength of physiological action and resistance; after confidence in his strength has returned to the patient, he must be warned to never again have confidence in his power of resistance with alcohol in his blood. Let him that thinketh he standeth then take heed lest he fall again. The cure of the drink habit is not always perpetual; it is not everlasting without the aid of the patient himself. Though to some the appetite never comes back, to others it is not safe to trust it with temptation. So that the safe plan, since no inebriate fully knows the full extent of his own inherent organic instability, is to "touch not, taste not, handle not," ever after. His treatment leaves him strong enough to say "No," and "Get thee behind me, Satan," to his tempter. It does not always leave him so strong that he can take the tempter to his bosom. He cannot always try a tussle with the tempter and not be thrown.

Tobacco Insanity.[1]

The deteriorating influence of tobacco-using upon the young was long ago recognized by the French government, leading to the prohibition of the use of tobacco by the students in the public schools. The Swiss government have taken even stronger ground upon this matter, forbidding the use of tobacco altogether to juniors. A boy found smoking in the streets is now promptly arrested and punished by fine or imprisonment.

Dr. Bremer, late physician to St. Vincent's Institution for the Insane, at St. Louis, has recently called attention to the fact that the use of tobacco by the young is productive of mental and moral deterioration, while in older persons the use of the weed produces brain disease and insanity. He attributes the obscure and unintelligible style of the philosopher Kant to his excessive use of tobacco, and he might with equal justice find in tobacco-using a cause for the notorious irascibility and pessimistic tendencies of the Scotch author Carlyle.

The editor of the *Review of Insanity and Nervous Diseases* an-

[1] Dr. J. H. Kellogg. Editorial in *Modern Medicine*, II, 10, Oct., 1893.

nounces his belief that many a nervous or idiotic child is the result of the tobacco-using habit of his parents. The baneful effects of tobacco-using are not so immediately noticeable as those of the liquor habit.

In view of the numerous facts pointing out the pernicious character of this drug, and the baneful effects of its habitual use, it is astonishing that physicians are not unanimous in their opposition to it. Still more astonishing is it that there are to be found many physicians who themselves indulge in the use of the weed. Dr. Bremer mentions the case of a physician who rewards his thirteen-year old son with extra strong cigars whenever he obtains high credit marks in school. It is astonishing that such a father should have a son capable of getting high credit marks. The physician, above all other men, should be free from habits which, like tobacco-using, are noisome, repulsive, and degrading.

Hemp Drugs and Insanity.

In an extended article under the above title, Surgeon-Captain J. H. Tull Walsh, of the Lunatic Asylums, Calcutta, discusses (in the Journal of Mental Science for January), the effects of the abuse of the various preparations of *Cannabis sativa*.

He concludes, 1, that hemp drugs are largely used in Bengal; smoked as *ganja* and *chunus*, drank as *bhang* and *siddhi*, or eaten as *majune*. The smoking of *chunus* and eating of *majune* are not very common.

2. Among healthy persons *ganja* smoked alone, with tobacco, or with a very small addition of *datura* (2-3 seeds) produces a condition varying from mild exhileration to marked intoxication. The violent intoxicating effects are less marked, or not seen at all, in persons having a regular and wholesome supply of food. Much the same may be said of *bhang*, etc.

3. Among persons of a weak mind, or with marked neurotic tendency, even a moderate quantity, or only a slight excess of hemp drugs, may so increase the insanity, evident or latent, as to make such persons violent, morose, or melancholy, according to the neuropathy with which we start. The presence of adulterations such as *datura* will increase these effects.

4. Abuse of hemp drugs, especially when adulterated with *datura*, will produce even in healthy persons a very violent intoxication simulating mania, or may lead to a morose melancholic condition, or to dementia. These conditions are generally of short duration, and the patient ultimately recovers.

Melancholia.[1]

In an interesting article by the Assistant Superintendent of the Carlisle Asylum, much statistical information is conveniently given.

In the English asylums it appears that there are, on the average, two cases of mania to one of melancholia. In passing it is noted that short strikes produce a decrease in insanity, perhaps because of diminution of intemperance and the bracing effect of the excitement; on the other hand a prolonged depression of trade causes an increase of insanity.

Additional (though unnecessary) proof is adduced to show that melancholia is more common among women than men. Almost 58 per cent. of all cases of melancholia recovered. Over 65 per cent. of all cases evinced suicidal tendency. The melancholia was associated with marked physical disease in over 28 per cent. of the cases, phthisis being the most common.

Mental Perversions in Children.[2]

In the very instructive paper quoted we find a collection of much that has been written upon this subject with useful additions. The fact that "from puberty, brilliant talents, astonishing facility of receiving and communicating ideas often appear suddenly, especially in females, followed by mediocrity, disappointment and supineness," as stated by Parkman, throws great responsibility upon the teacher.

It is often within the power of a careful parent, teacher or friend to determine whether the scale shall drop on the side of morbid sentimentality introspective and neurotic melancholia, ending in a perverted or dangerous life or on the side of judiciously controlled enthusiasm and high attainment. Teachers must not forget that children of the same age physically are not coördinate mentally, nor that the various faculties are not always developed in the same order. A case has fallen under the present reviewer's notice where the child of intelligent parents, born with imperfect physical development and head distorted during parturition, was found to be far inferior to others of the family in mental grasp for several years and was well nigh permanently injured by injudicious forcing, in which she was continually made conscious of the disparity between herself and her brothers. A change

[1]Farquharson, W. F. On Melancholia: An Analysis of 730 consecutive cases. *Journ. Med. Science*, XL, 168, Jan., 1894.

[2]Alexander, Harriet C. B. Insanity in Children. *Alienist and Neurologist*, XV, 1.

of circumstances and encouragement, taken together with nutritive diet, stimulated the tardy powers and she was able to hold her own with ease.

A suggestion quoted from Turnbull deserves to be given consideration by those responsible for the deplorably vacuous material on which our children are expected to feed in the public schools.

"They should be induced to read what would be a benefit and a delightful resource in after life—the tales of Grecian mythology, the poems of Homer and other classics, popularized science, tales of adventure," etc. The present writer believes that he is more indebted to the fact that early seclusion left him to make what he could out of "grown up books" at the age when modern children are kept upon stuff written down for their capacity by mediocre would-be authors, than to all the primary schooling afforded him.

But, to return to the paper before us, let us quote the following from Dr. Mary Putnam-Jacobi:

"In neuropathic families the children early manifest a remarkable nervous excitability, with tendency to severe neurotic disorders at physiological crises, as convulsions during dentition, neuralgias at menstruation. The establishment of menstruation is often premature, often preceded and followed by profound chloro-anæmia. The cerebral functions are easily disturbed, slight physical disorders being attended by somnolence, delirium, hallucinations. The nervous system seems to be everywhere hyperæsthetic. Reaction to either pleasing or displeasing impressions is excessive; there are abundant reflex neuralgias, vaso-motor irritations. Pallor, blushing, palpitations, præchordial anxiety, are caused by trifling moral excitement or by agents lowering the tone of the vaso-motor nerves, as heat or alcohol. The sexual instincts are precocious and often perverted. The establishment of puberty is often the sign for the development of spinal irritation, hysteria or epilepsy. The psychic characteristics correspond. The disposition is strikingly irritable, psychic pain arises for trifling cause; on the least occasion the most vivid emotions are excited. The subjects of this temperament alternate rapidly from one extreme to the other. . . . On the other hand there is a remarkable inexcitability of the ethical feeling. Vanity, egotism, and a jealous suspiciousness are common; and the temper is often violent. The mind is often obviously feeble, with few and monotonous ideas, and sluggish association of them. At other times ideas are readily excited; the imagination is active even to the production of hallucinations; but mental activity is ineffective, because of the rapidity with which it leads to exhaustion. There is no time to complete anything before the energies flag. The will is equally deceptive in its apparent exuberance and real futility."

Such is the general picture of a child with neuropathic heredity, but the possession of some or most of these symptoms does not make it certain that the child will become a genius or a criminal; possibilities for either may be present while judicious care may ward off either of these calamities.

Different from this class is that of moral imbeciles. As Mills says, "the subject of true moral imbecility is the victim of heredity, and his condition is manifested as soon after birth as it is possible to recognize deficiencies in the moral sense through conduct. . . . Such children are incorrigible to reproof and training." Moral insanity, on the other hand, is secondarily induced by trauma or excess. Many authorities agree that for these classes a special training with sequestration is necessary. Ordinary educational methods either increase the disorder or give to its possessor greater power for evil, not to speak of the effect upon associated children.

Our author calls attention to the additional evils wrought by permitting the degenerate parent to control the child. From 10-30 per cent. of infantile insanity is attributable to the acute diseases of childhood. Spitzka states that sudden changes of temperature uncomplicated by other causes can produce transitory frenzy and acute delirious states. A parasitic etiology (ascarides) has been proven for some cases, not to mention indirect influence, as where the irritation leads to masturbation.

The most frequent mental disturbance of children is idiocy, next maniacal excitement, while depression occurs only at a late period. Neuroses in children tend to be motor rather than sensory. Epilepsy and hysteria have the characteristic form and extreme cruelty may be the result of epileptic neurosis.

In children ideas are simple, few, and disconnected; they are, therefore, incoherent because of an absence of organic associations between the residua. Accordingly morbid phenomena are not systematized as in the adult, resulting in delirium rather than mania. The present reviewer recalls the case of a child of perhaps five or six years which seemed physically normal but whose conversation was of a most remarkably imaginative character; it would chatter on with the utmost volubility by the hour without coherence, but the detached sentences showed that the wildest flights of imagery were careening through its mind. Accompanying this was a morbid cruelty never observed in another child. Chickens were caught, tortured and dismembered and other children as well as domestic animals were never safe within its reach.

Homicide and suicide are not as infrequent among children as most people suppose. 6.1 per cent. of the suicides in England are of children under ten years. Many cases can be referred to over pressure in the schools.

The morals which may be drawn from the facts noticed above are: 1, that teachers should receive such instruction in practical neurology as shall enable them to recognize and properly deal with the frequent cases of hereditary neuropathy under their care; 2, school boards should sufficiently take the responsibility devolving on the teacher as to be willing to pay salaries which shall make such thorough and practical training possible; 3, the teacher should feel it a part of her duty to become acquainted with the home status and indications of heredity in order to more clearly understand the morbid conditions presented; 4, the teaching force should be large enough to admit of such supervision and the course should be flexible enough to provide for incipient perverts and children with retarded development; 5, there should be some provision for a periodic psychometric examination in all large schools and a competent medical expert should occasionally "visit" each room. C. L. HERRICK.

Myxœdema.[1]

The interest in the remarkable mental derangements accompanying myxœdema does not abate. Dr. Clouston reports upon nine cases. Few varieties of mental disease afford so simple causation. In the body at large, while little irritation or inflamation can be detected, the various tissue cells seem to be separated by a deposit of mucin. Depression of the vascular function and heat formation is characteristic. In the nervous system the greater complexity of structure and function forbid us from expecting a similar uniformity in the symptoms. All myxœdematous patients have lowered vaso-motor tone, lowered temperature, slowness in speech, walking, etc. and the reaction time is prolonged in all cases. With sensory disturbances greater variety is apparent with much allowance for personal equation. In some cases marked anæsthesia and analgesia. Memory suffers in most cases. Memory of recent events, as well as of certain selected events, suffers and

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[1]CLOUSTON, T. S. The Mental Symptoms of Myxœdema and the Effect on them of the Thyroid Treatment. *Journ. Mental Science*, XL, 168.

paræsthesia was present in seven out of nine. Attention is always im paired and curiosity is diminished. Sensory aura is frequent. Indifference in affections and suspicion are frequent. The intellectual powers are characterized as sluggish rather than perverted. Volition especially is impaired and loss of inhibition is evidenced, but typical dementia is not reached. In those cases where thyroid treatment was resorted to the cure was affected though the fact was brought out that the effects of the long-standing malady may long remain latent even after all apparent signs have disappeared. Caution is necessary in the use of the remedy.

The cortex of a myxœdematous patient was examined. Since the person was sixty years old it remains doubtful whether the slight thickening of the pia, increase in spider cells, pigmentary degeneration of cortical cells, increased fibrilation of the neuroglia, increase of nuclei in the walls of the vessels, and other points reported are not results of senile change.

The article closes with the hypothesis that the neuroglia of the cortex becomes to a slight degree water-logged [sic] by mucin, which causes lowered anabolism and katabolism of the cells, whose reactiveness is thereby impaired.

A Complicated Case of Aphasia.[1]

Patient, 66 years old, slightly demented, after apoplectic stroke acquired complete right hemiplegia speech disturbance, hemianopsia. After five months dementia well-marked, temperature sense and sense of position and muscular sense absent on the right side. Later the power to distinguish colors was lost and the right knee reflex was greatly exaggerated. Autopsy revealed a softening of the central convolution and part of insula (1 cm. long) and similar amount of the operculum and temporal lobes. The supra-marginal and both the adjacent parietal convolutions were involved. The entire orbital aspect of the frontal lobes markedly atrophied. Blood vessels at the base atheromatous.

Sections showed atrophy of the cortex especially marked over the superior temporal convolution. A small focus of softening was found in the cerebellar vermis. Diffuse atrophy of the callosum, total degeneration of the left internal capsule, partial degeneration of the left optic tract, almost complete cellular obliteration in the external geniculate body and a degeneration of the right lateral pyramid complete the

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[1]Bleuler. *Archiv f. Psychiatrie u. Nervenk.*, XXV, 1893.

picture. Phrenoplegia or deficient kinæsthetic sensation manifested by loss of muscle innervation is located according to Nothnagel in the temporal lobes.

Although the patient had complete alexia and could not read the letters he recognized that his written name represented him. In spite of the destruction of the insula he was able to sing and recite.

Developmental General Paralysis.[1]

A phase of general paralysis sustaining some relation to the periods of puberty or adolescence was first so named in 1890, by Dr. Clouston. The present paper is occupied with clinical and pathological notes on a number of cases. Both classes of phenomena exhibit nothing unusual in general paralysis.

The disease seems to develop at about 15 years and the cases reported are all females. The uterus and ovaries were still in the infantile stage.

Syphilis seems to be an important factor in these cases. The atrophy of the cerebrum is marked, the average brain weight being 27½ oz.

Cerebral Tumor Diagnosed by Means of Focal Symptoms.[2]

Patient was a man 41 years old, without specific history. About five years prior to operation a sharp cramp-like pain of great severity suddenly appeared in the calf of the right leg. This was followed one week later by another and these continued to appear at intervals of from 7 to 10 days. A prickly paræsthetic feeling in the locality of the monospasm preceded it. These spasms extended until the right arm was involved, but always originated in the same place; the whole side was affected in the course of one year. Weakness of the limb increased as the case progressed.

Examination showed right motor paralysis and sensory blunting of right leg; the right patella reflex was exaggerated. Hearing was affected in the right ear. Diagnosis: Cerebral tumor in the leg region. Operation: A horse-shoe flap 3 in. wide was turned down and fixed by a stitch. The skull was opened to almost the same extent. Palpation revealed resistance over one inch on either side of upper third of Rolandic fissure. A tumor of considerable dimensions was found extending into the brain but separable from it with a few slight adhe-

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[1]MIDDLEMASS, J. *Journ. Mental Science*, XL. 168, Jan., 1894.

[2]STEELE, A. K. *Journ. Am. Med. Assoc.*, XXII, 4, Jan. 27, 1894.

sions. A firm pedicle was found attached to the skull or falx at the region of the longitudinal sinus. The tumor was shelled out and then the capsule and pedicle were removed with the curette. A large rent in the superior longit. sinus resulted, which caused profuse hemorrhage, which was controlled by gauze packing. Dressing was applied for three days, after which most of the gauze was removed—all of it after four days more. After the operation complete motor paralysis of arm and leg for 24 hours, which continued to diminish until nearly complete restoration. The tumor was diagnosed as endothelial fibro-sarcoma.

Microscopical Changes in Huntington's Chorea.

Greppin reports a case, age 51, marked by dementia, refusal of food, somnolence and general choreic movements. Autopsy revealed pachymeningitis and leptomeningitis, also sclerosis of the septum cranii. Convolutions were flattened and slight atheroma of vessels of the base. Microscopic examination showed accumulations of nuclei in both gray and white matter. Ganglion cells were sometimes obliterated by them and the vessels whose walls were modified. In many places these cells are agglomerated, losing their nuclei and making a formless mass. The masses are distributed in the white matter of the temporal, parietal, and frontal convolutions and in the cortex of the insula and in the white matter of the cerebellum. They were less numerous in the central ganglia, pons, and medulla. The medullated nerves were reduced and the myelin sheaths swollen. The author considers the cells modified connective tissue elements and considers the case one of non-purulent encephalitis.

The author differentiates the pathological state from that of general paralysis by the statement that in the latter there are chiefly alterations of the vessels and great modifications of Deiter's cells, while in chorea there is a multiplication of cell elements. (*Schmidt's Jahrb.*, June 15, 1893.)

Pathology of Hay Fever.[1]

Dr. S. S. Bishop states that hay fever is due to an excess of uric acid in the blood. Attacks may be prevented by reducing the amount of uric acid to the normal or may be cured by precipitating the excess of this substance. Leflaive found uric acid in great excess just prior

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[1]A New Pathology and Treatment of Nervous Catarrh. *Jour. Am. Med. Assoc.*, Nov. 25, 1893.

to attacks of hay fever. The effect of an excess of uric acid in the blood vessels is to contract them, which, in the case of the brain, produces cerebral anemia, and this condition appears to maintain in hay fever. The fact that excess of uric acid is found in connection with so many diseases of unlike complexion should inspire caution in accepting radical conclusions on a slender basis of observation.

Hysteria in the Vendee.[1]

The Vendean peasant possesses a remarkably impressionable emotional nature. Hysteric men and women are legion. Three fourths of patients who come for consultation have nervous troubles. Also remarkable is the readiness with which the Vendean obeys suggestion, —the frequent and effective use of hypnotism in the treatment of hysteric neurosis.

The author's purpose (in which he was encouraged by Babinski, whom he had a consultation with) is to state the result of his experiments concerning the part that hypnotism may play in nervous diseases, particularly in hysteria. He endeavors to prove:

(1). That hypnotism is an excellent method of treating hysteric accidents,—paralyses, contractions, spasms, etc.,—in hypnotizable subjects.

(2). That in non-hypnotizable subjects recourse must be had to suggestion in a waking condition, since this affords excellent results, giving to various methods of treatment employed a value, an effectiveness otherwise not attainable.

(3). That if the effectiveness of hypnotism is such in hysteria, on the other hand it offers no help in the treatment of other nervous ailments, to say nothing of organic affections; that, if a result is obtained, it is only absolutely transitory, momentary; that, if we sometimes note a lasting improvement, it is because these nervous ailments or organic affections are not alone, that hysteria happens to be associated with it, and that it is the removal of these hysterical troubles that, by causing the patient's improvement, has caused the belief in the beneficent action of hypnotism on various diseases.

As is seen, I am of the opinion, contrary to the contention of the Nancy school, and in conformity to the Salpetrière doctrines, that close relations exist between hysteria and hypnotism.

As regards the role of hypnotism in therapeutics I share the view

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[1]DR, TERRIEN. De l'Hystèrie en Vendèe. *Archives de Neurologie*, December, 1893.

of Babinski,—that hypnotism can have therapeutic action only upon the manifestations of hysteria.

(4). Finally, I shall try to explain the frequency of neuropathic affections in the Vendée. Is it due to alcoholism, to the so numerous consanguineal marriages? Must we conclude also that hysteria is more easily developed in a new, primitive country, excessively superstitious? Are these three causes combined?

In chapter I an account of ten cases of hysteria involving aphony, astasia, and abasia, anorexia, spasm, hyperesthesia, paresia, gastralgia and vomitings, agoraphobia,—all hypnotizable and all cured, usually by a single treatment.

In chapter II five cases of adults cured by suggestion while in a waking condition, affections involved being much the same as in chapter I.

Chapter III treats of associated hysteria; the cure of hysterical troubles by hypnotism, but the persistence of troubles due to concomitant diseases.

In chapter IV the remarkable frequency of nervous diseases in the Vendée is explained. It is due not to the causes that produce hysteria and neurasthenia generally: excitement of city-life and alcoholism; but to marriages of kindred, and to superstition.

The editor, Bourneville, in a note dissents in part from this explanation. The true one, he says, is neuropathic heredity, intensified, doubled by consanguineous marriage.

G. F. McKibben.

Miscellaneous Pathological Notes.

Dr. Peterson exhibited before the New York Neurological Society, Dec. 5, 1893, the brain of a female infant aged 20 months, which had suffered from congenital diplegia-spastic paralysis of the four extremities. There were convulsions and enormously exaggerated knee-jerks and ankle-clonus. The head was very small and the sutures closed. A large group of convolutions especially of the motor area were absent. Degeneration and atrophy of the lateral columns of the cord.

Dr. Peterson also exhibited the brain of an 18-months child with chronic hydrocephalus and lacking the hemispheres. The cerebellum was of the normal size. There was degeneration and atrophy of the lateral columns of the cord. The child was blind and had nystagmus. There was rigidity of the extremities and convulsions.

Dr. Wiener reported a case of unilateral bulbar palsy. A few months before the glands of the neck were removed on account of tubercular disease. Complete unilateral palsy of the right side of the tongue, soft palate, pharynx, and right recurrent laryngeal nerve developed. Autopsy showed the nidulus of the 12th nerve greatly altered on the right, and less so on the left. Niduli of the ninth, tenth and eleventh nerves were somewhat affected. The respiratory bundle appeared completely degenerated on the right side, while on the left, in the region of the hypoglossus nidulus its ventral and cephalic parts were diseased. No evidence of tubercular disease was found and the change was considered motor atrophy.

Dr. Wiener summarizes as follows:

1. The region of the hypoglossus nucleus gives origin to nerve fibres which supply the tongue, palate, pharynx and larynx on one side of the body.

The column of nerve fibres known as the respiratory bundle consists of fibres from the glosso-pharyngeal, vagus and vago-accessorius fibres.

3. The glosso-pharyngeal nerve seems to control the reflexes of nausea and gagging in the soft palate and pharynx, and also to send some of the motor filaments to the pharyngeal muscles. These latter filaments take their origin in the hypoglossal nucleus and ascend in the respiratory column to the nucleus proper and then make their exit with the glosso-pharyngeal nerve.

4. The soft palate muscles are not innervated by fibres from the seventh nerve. (*Journ. Nerv. Mental Diseases*, Jan. 1894.) This case may be compared with that recorded by Reinhold (*Deutsch. Zeitsch. f. Nervenheilk.* Oct. 1893.) which had been reported as one of bulbar paralysis. After 12 years, during which the symptoms had not changed, the patient died of bronchitis and microscopic examination showed no structural changes. The case proved to involve primary disease of the muscles. "Dystrophia muscularis progressiva."

In his paper on Hereditary Spastic Spinal Paralysis (*Deutsch. Zeitsch. f. Nervenheilk*, Oct., 1893.) Strümpell states that:

1. Under the influence of an abnormal hereditary defect there develops, slowly but progressively, a primary systematic degeneration of the crossed pyramidal tracts.

2. The symptoms (primarily sharply limited spastic disturbance of the lower extremities) develop between 30 and 40 years of age.

3. After the lapse of years the disease generally becomes a true spastic paresis and paraplegia of the legs.

4. As a rule, the pathological changes limit themselves to a de-

generation of the pyramidal tracts with slight degeneration of other systems, particularly the direct cerebellar and Goll's columns.

Innervation of the Heart of the Frog.

W. NIKOLAJEW, in the *Arch. f. Anat. u. Phys.*, suppl. for Phys. Part, 1893, offers a preliminary study which may be summed up as follows:

The vagus of the frog contains fibres which end in the pericellular nets and whose origin is in the medulla. Since the pericellular net simply lies upon the protoplasm of the nerve cells without entering the cell substance, the influence on the nerve cell must be by contact simply. The pericellular net is accordingly analagous with fibre-endings within the central system.

Nerve-Termini in the Lachrymal Gland of Mammals.

Professor A. S. Dogiel[1] comes to the following conclusions respecting nerve-termini in the lachrymal glands: (1). Its fibres, which surround the blood-vessels and ducts and for the most part enter with them, are almost exclusively nonmedullated. (2). The nerve fibres and branches produced by their division surround the tubules with few loops and form a meshwork lying upon the membrana propria. (3). From this network fine branches and fibres pass out and pass through the membrana propria. These fibres gather about the bases of the glandular cells and by crossing and blending form a supracellular network. (4). Very small fibres pass from the last mentioned and form an inter-cellular network in whose meshes the cells lie. (5). The occasional appearance of free termini is misleading being due to imperfect coloring.

The above arrangement is considered typical for all serous if not all mucous glands.

The author seems unaware of the work of Dr. Berkley along similar lines.

The Course of the Optic Fibres in the Frog.[2]

The author found Marchi's method imperfectly applicable to the study of degeneration phenomena in cold blooded vertebrates and accordingly employed Weigert's process for the most part. The devel-

[1] *Arch. f. mik. Anatomie*, XL, 4.

[2] WLASSAK, R. Die optischen Leitungsbahnen des Frosches. *Arch. f. Anat. u. Phys.* Phys. Abth., 1893, Supplement.

opment of the medullary sheaths was used as a check on the results obtained by degeneration.

Three distinct portions of the optic tracts are distinguished:

1. The axial bundle is the first to become medullated and lies adjacent to the lumen of the nerve. The fibres cross after entering the diencephalon. This is the bundle which Köppen called the thalamus root of the optic nerve. It may be followed to the roof of the tectum and there dips below the external layer and is lost in deeper cell series. These fibres may be recognized as the most dorsal of those crossing in the chiasm. Wlassak finds, like Bellonci and Herrick, that the fibres do not terminate in the corpus geniculatum. The fibres end in two layers and form the 3d and 4th fibre layer of the tectum counting from the periphery.

An attempt to explain the origin of the myelin seems to the writer to rest on very imperfect data.

2. The second tract is called the marginal bundle and passes superficially to the tectum without forming connections in the diencephalon but enters the tectum superficially to the axial bundle.

Wlassak seems to confuse the Sylvian commissure, which he correctly describes as connecting the two tecta, with the post-commissure. In fact the continental writers generally, since Stieda, have failed to recognize the fundamental difference, though Edinger refers to it.

3. The third tract is the basal bundle which terminates in niduli, near the median line, cephalad of the oculo-motor niduli, i. e., in the basal optic niduli.

This bundle is identified with that recognized by Edinger in Amphibia, and by Singer and Münzer and Perlia, in birds. Of the interoptic commissures one arises in the corpus posterius of Bellonci (testis) and passes mesad of the ventral part of the optic tracts to a decussation with the latter; the part is identified with inferior commissure of Gudden. The second part is homologized with Meynert's or Forel's commissure and lies adjacent to the axial optic tract. It finally becomes the most superficial layer of the tectum and terminates at the other extremity in the gray matter of the diencephalon. The system receives a new name, "opticoid bundle."

To the above it may be said that it is wholly incomprehensible, providing no connection between optic tectum and cerebrum. It is also quite inconsistent with results of the present writer. Much would be gained if in the midst of the furor for modern fibre methods and silver impregnation occasional resort could be had to methods which reveal both and stain uniformly. The axis cylinders of the axial bundle end freely in the tectum. The marginal optic bundle arises from axis cylinders from cells of one of the deep layers. In these respects the results agree with Herrick's in the fish, reptile and amphibia, but we do not think the layers are capable of such close discrimination as that attempted by Wlassak.

The author did not succeed in applying the method of degeneration to the tectum and does not make the very desirable comparisons with the Urodela and other groups. The paper, nevertheless is very serviceable, especially as it is introductory to physiological work.

We hope similar care may be used in seeking the cerebral connections.

Histology of the Optic Nerve and Tract.[1]

Professor S. E. Hensen finds the path of the optic stimuli to be composed of fibres from the large ganglion cells of the retina which end in the geniculate bodies, and other fibres arising in cells of the geniculata and ending in the cortex of the occipital lobe. The course and position of the fibre bundles is as follows: The macular bundle, which at the papilla lies latero-ventrally, becomes more central as it passes centrad, and is the central bundle in the chiasm and tract. The uncrossed fibres at the papilla form two bundles, a dorso-lateral, and a ventro-lateral, separated by the macular fibres; further back these unite to form a lateral bundle. The crossed fibres at the papilla lie in a medial or dorso-medial plane and retain this position throughout their course. On entering the chiasm, the uncrossed fibres, which have hitherto formed a compact crescentic bundle, divide into a number of horizontal rays which alternate with similar rays formed by the crossed fibres. A certain proportion of the uncrossed fibres keeps its course at the periphery of the chiasm, but most of them pass medially, intermingling with the crossed fibres. The crossed fibres in passing through the chiasm, change from the dorso-median position to a ventro-median position in the tract. The uncrossed fibres also change, occupying in the tract a latero-dorsal position. Fibres representing the dorsal half of the retina run dorsad in both bundles. These bundles remain separate as far as to the geniculatum where they coalesce. The optic fibres, in part, form the capsule of the geniculate body and, in part, enter it, forming the so-called medullary lamellæ. The geniculate body is, therefore, the main visual ganglion, though fibres can be traced to the

[1]Om Synbanans anatomi ur diagnostik synpunkt. Upsala, 1893.

pulvinar and anterior quadrigemina. These latter fibres, however do not seem to transmit visual impressions and a lesion there does not seem to cause a defect in the visual field. From the ganglion cells of the geniculate body fibres pass backward into the occipital optic tract. They form a compact fasciculus about 5 mm. in diameter, which passes at the level of the first temporal fissure and second temporal convolution backwards to the bottom of the calcarine fissure. In this optic path the fibres for the dorsal half of the retina lie dorsad, as in the anterior part of the tract. The cortical visual centre lies at the bottom of the calcarine fissure, and is restricted to it. A unilateral lesion in this fissure causes complete hemianopsia. The pulvinar and quadrigemina are also connected with the cortical visual centre; these are probably reflex paths. The theory that the visual tract takes part of the formation of the internal capsule or decussates behind the chiasm is incorrect. The macula is often innervated from both sides of rhe brain.

The Roof of the Diencephalon in Petromyzon.[1]

In a brief paper, full of interesting suggestions, Professor Burckhardt indicates the inappropriateness of the term lobus olfactorius impar, as proposed by Kupffer, and substitutes recessus neuroporicus, which should be at once adopted.

The pineal stalk enters the lower pineal vesicle not the upper, as supposed by Ahlborn. But the two communicate as indicated by the latter author. Burckhardt finds the prepineal segment or "polster," followed by the velum and paraphysis, as in other vertebrates. In the later stages there is a retrogression rather than development in these parts. From this and other recent communications it appears that there is now no difficulty in applying homologies throughout the vertebrate series.

The Effect of Reflex and Central Irritation of the Optic Nerve upon the Position of the Cones in the Retina.

NAHMMACHER has investigated the retina of the frog with the view to determine whether contraction of the cones is produced by the irritation of centrifugal fibres. It will be remembered that Grijns has determined physiologically the existence of such centrifugal tracts

[1]BURCKHARDT, R. Die Homologien des Zwischenhirndaches und ihre Bedeutung für die Morphologie des Hirns bei niederen Vertebraten. *Anat. Anzeiger*, IX, 5-6.

as Engelmann assumed (retinomotor fibres.) Gotsch and Horsley have found that irritation of the dorsal root fibres of the cord produces negative variation in the corresponding fibres of the opposite side. This suggests the possibility of the transference from one sensory path to another.

His, Herrick, Monakow, Cajal and others have demonstrated in various groups the existence of centripetal and centrifugal tracts. (See also Wlassak, Die Optischen Leitungsbahen des Frosches, in *Archiv f. Anat. u. Phys.*, 1893, Suppl. to Phys. Part, who makes the relations clear in the frog itself.)

Three positions of the cones are distinguished, a proximal, intermediate and distal. In the proximal position the average length of the myoid, or terminal portion, from the limitans externa to the proximal end of the ellipsoid, is one or one and a half the length of the ellipsoid itself. The spheroid of the cone lies near, generally above, the limit between inner and outer segments of the rods, at any rate all within the lower third of the space between limitans externa and the under surface of the bodies of the pigment cells.

In the intermediate position the majority of the ellipsoids lie in the middle third of this space and their myoids are narrow and two to four times as long as the ellipsoid, while in the distal position the ellipsoids occupy the upper third of the space and have a slender thread-like myoid. Irritation of one eye with salt solution while the optic nerve remained intact, caused the ellipsoids in the other retina to assume the proximal position in 86.6 per cent. of the cases, while if the optic nerve had been resected only 24 per cent. were in this position. The exceptions are explained in various ways.

Direct irritation of the optic nerve or chiasm produced proximal position of the ellipsoids in 82.3 per cent. of the experiments while in control cases only 18.4 per cent. were found in this position. These experiments are thought to afford physiological support to the anatomical theory of centrifugal fibres in the optic nerve.

The Structure of the Electric Organ of Torpedo.[1]

This elaborate monograph on the nervous termini in the electric organ cannot be condensed for review here. It details the results of extended applications of the Golgi method to these organs and claims to set at rest many of the moot points. A considerable portion of the

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[1]Ballowitz, E. Ueber den Bau des Elektrischen Organes von Torpedo, etc. *Arch. f. mikr. Anat.* XLII, 3.

paper consists of critical reviews of previous work. The position of Boll is supported and that of Fritsch is severely handled. A full bibliography accompanies. It is hoped to secure a comprehensive review of this subject for the Journal at an early date.

The Brain of Limulus.[1]

We are glad at last to announce the appearance of this work for which we have been some time prepared. It forms a bulky quarto with thirty-six plates and numerous figures all elegantly engraved. Viallanes has described the brain of Limulus and given figues of models reconstructed from sections. Kishinyone and Patten have also added embryological data.

Professor Packard states that the brain is composed of three pairs of lobes, i. e., two pairs of eye-lobes or ganglia, viz.—first those which send nerves to the lateral eyes; second, those which innervate the median eyes; and third, the cerebral ganglia, which, with the mushroom bodies, form the chief portion of the brain. The ganglia of the first pair of appendages are separate from the prestomal brain mass and are consequently excluded from consideration with the brain proper. Packard rejects Patten's second pair of median eyes. Viallanes' classification of the regions of crustacean and insect brain into three does not apply to Limulus. Viallanes' "protocerebrum" is that which Packard considers the brain proper.

Packard accepted Viallanes' identification of the so-called nucleogenous bodies with the pedunculated or mushroom bodies of insects. There is little doubt that the brain is in its general features much like that of Arachnida. The organ described by St. Remy as the "organe stratifie posterieur" in spiders is considered as the homologue of the mushroom body of insects in spite of the fact that it is not double. Two other bodies noted by St. Remy, the "olivary body" and "organ en bissac" are said by Packard not to occur in the king crab.

Little embryological matter was added to that published by Kishinyone and Kingsley. Although many sections were prepared the fine histology is imperfectly made out, owing no doubt to the great difficulty of securing a suitable technique. It is to be hoped that something approaching the methyl blue process may be applied to this subject.

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[1]PACKARD, A. S. Further studies on the Brain of Limulus polyphemus with notes on its Embryology. *National Academy of Sciences, Memoir 8.* Vol. VI.

We miss from the bibliography reference to Nansen, whose histological studies certainly should be consulted in any study of crustacean neuro-histology.

Invertebrate neurology owes thanks to our veteran entomologist for the valuable work before us.

The Connective Tissue Skeleton of the Spinal Cord.[1]

Sections of the spinal cord hardened in Müller's fluid and stained with acetic hæmatoxylin and afterwards differentiated with Weigert's borax-ferricyanide of potassium in very dilute solution, exhibit superficially a very sharp differentiation between gelatinous connective tissue and neuroglia.

The gray cortical layer of the cord and the septa passing from it inward consist of a tissue which is sharply distinguishable from gelatinous connective tissue.

The superficial glia-layer (subpia of Waldeyer, gray cortical layer of older authors) exhibits great individual variation. It is thickest at the lips of the sulci and exits of the nerves. Where most developed the fibres have a circular, radial, and longitudinal course, forming a meshwork connecting directly with the glia septa. All vessels and septa from the pia are clothed with such a glia coating.

The greater number of radial septa are of glia nature, but a considerable number of irregular connective septa arise from the pia. Larger masses of connective tissue follow the vessels and these together constitute a considerable element in the framework.

Ganglion Cells and their Spongioplasmic Skeleton.[2]

The author continues his studies upon the microscopic structure of the invertebrate ganglion cell, founding his studies on Leydig and Nansen.

As Leydig said there is such a blending of the spongioblastic frame-work of the cell with the connective tissue surrounding that it is impossible to say where one terminates and the other begins.

Numerous examples are chosen from gasteropod mollusks. Two sorts of spongioplasm fibres, fine and coarse, and a considerable va-

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[1] SCHAFFER, J. Die oberflächliche Gliahülle und das Stützgerüst des weissen Rückenmarks-mantels. *Anat. Anz.*, IX, 8.

[2] ROHDE, E. Ganglionzelle und Neuroglia. *Arch. f. mik. Anat.*, XLII, 3, 1893.

riety in the connections affected with the enveloping mesh-work (which is called "neuroglia" by Rohde) are described.

The same relations are found in a large number of crustaceans, and an attempt is made to bring these relations into harmony with facts observed by Fritsch, in *Lophius* and *Malopterurus*.

Rohde passes to a comparison with the conditions described by Dohrn.[1] It may be remembered that Dohrn described in sharks, the formation of a sheath about the cell by a process of fusion of nerve cells which form about it. Inasmuch as these could not, as he then thought, be of mesodermic origin, he concluded that the peripheral layer of the ganglion cell is formed by the fusion of these encapsuling nerve cells.

Rohde thinks the relations are similar to those he describes in *Tethys* and *Pleurobranchus*. Dorhn has since yielded to the overwhelming German influence and denied the ectodermic origin of the sheath cells, but Rohde (and many others) think the original view the correct one. These considerations lead the author to doubt the cellular nature of ganglion cells.

To the present writer there seems a simpler escape. The peripheral nucleated sheath of the ganglion cell is formed precisely as the sheath of the fibre is by the subdivision of the primitive neuron and the sheath is but a special form of what is found throughout the nerve. Passing to the invertebrates, we have no right to project conditions of comparatively late origin among vertebrates so far backward. The term neuroglia has no place in describing invertebrate nervous structures, certainly not when applied to the immediate sheath of a fibre or cell. The concentration into a central system is on a much simpler plan than in vertebrates. Even in Amphioxus there is no neuroglia. The structures described as neuroglia are really spongioblastic and the sheath formation is of necessity greatly accentuated.

[C. L. H.]

The Embryology of the Hypophysis of Saurians.[2]

This short paper includes an account of the earlier stages of the pituitary of lizards. In saurians and perhaps all reptiles the hypophysis has a three-fold proton (anlag) consisting of a median and two lat-

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[1]*Mittheil. aus der Zool. Station zu Neapol* X, 2, 17. Studie zur Urgeschichte der Wirbelthierkörpers.

[2]GAUPP, E. Ueber die Anlage der Hypophyse bei Saurien. *Arch. f. mik. Anat.*, XLII, 3.

eral buds. The middle one behaves like the mammalian hypophysis, while the lateral ones are temporarily united with the median one and then acquire an independent relation with the brain, separating from the hypophysis in the form of solid epithelial bodies.

The figures show that in Lacerta agilis there is a well-developed "Seessel's recess[1]" which corresponds to the structure described by Mr. Bawden in the June number of this Journal for 1893.

Changes in Brain Tissue Due to Hardening Reagents.[2]

It is a matter of the first importance to the histologist to be able to distinguish those appearances due to the reagents employed from those which express the normal state of the tissue and among these in turn to distinguish those which arise from functional changes.

The investigations conducted by Dr. Donaldson have been under most favorable auspices and have been facilitated by grants of money, abundant material, and competent assistance, etc.; we naturally expect, therefore, very considerable results in this tedious but valuable investigation. This preliminary paper, however, is limited to the effects upon the weight of entire brains or large portions of such brains by a few of the common reagents. It thus gives an accurate mathematical statement of the changes with which all histologists have become more or less familiar in practice. We look forward with interest to the application of similar methods to the more important questions of histological alterations.

It is impossible to reproduce the tables which show at a glance the change of weight resulting by varying the time or density of the fluid. They will be of considerable value in the laboratory.

The Auditory Nerve-termini in the Brain of the Cat.[3]

Dr. Paul Martin contributes several particulars to the recent researches of Sala, Held and Kölliker, on this subject. We excerpt his summary:

1. The fibres of the cochlear nerve divide, soon after their entrance into the ventral nidulus, into a division passing medio-cephalad

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[1]Zur Entwickelungsgeschichte des Vorderdarms. *Arch. f. Anat. u. Phys.*, 1877.

[2]Donaldson, H. H. Preliminary Observations on Some Changes Caused in the Nervous Tissues by Reagents Commonly Employed to Harden Them. *Journ. Morphology*, IX, 1.

[3]*Anat. Anzeiger*, IX, 5-6.

and medio-caudad and then divide into numerous branches as described by Kölliker.

2. The small multipolar cells of the ventral nidulus are recognized. The nervous processes are always short and, as Held says, divide frequently.

3. Adjacent to the above he finds the large nerve cells described by Kölliker, but many of them have the appearance of an ordinary multipolar nerve cell. From a rather far ventral large cell a mesoventral process could be followed into the corpus trapezoides. Finally fusiform cells were found with dendrites at either end. In two of these the nervous process at its proximal end exhibited a very large polar dendrite and such cells as these may have led Sala to the assumption of bipolar ganglion cells with T-shaped fibres. In the case observed there is no doubt that a nervous process arises from a dendrite. In the tuberculum acusticum are similar fusiform cells lying mostly in a transverse position, yet it was impossible in most cases to trace the processes far in the tuberculum acusticum, while in those of the ventral nidulus they all tend toward the corpus trapezoides.

4. A large part of the fibres entering the tuberculum acusticum first pass through the ventral nidulus and give off collaterals to it.

5. Cochlear fibres are also found which pass mesad of the tuberculum acusticum and end far dorsad in terminal brushes in the most distant parts of the tuberculum. Held identifies certain other fibres which pass from this point and, arching about the restiforme, pass again ventrad as a part of the root-fibres of the cochlearis, but Martin is not sure that they do not originate from cells of the tuberculum.

6. Besides the termination of the vestibular nerve in the two dorsal terminal niduli of Kölliker (dorsal or main vestibular nidulus or Deiter's nidulus) as well as in the region of the caudal root, the whole gray mass between the floor of the ventricle, the caudal trigeminal root and the corpus restiforme may be considered as a terminal region of the vestibular nerve as also a partially distinct portion of ventral nidulus beneath the restiforme.

Chromatophores of Cephalopods.[1]

The chromatophores of *Loligo*, for example, consist of a pigment cell with twenty or more long radial fibres. These fibres have been supposed by the older authors to be muscular and their purpose to

[1] SAMASSA, P. Bemerkungen über die chromatophoren der Cephalopoden. *Verhandl. natur.-hist.-med. Vereins zu Heidelberg*, V, 2.

produce the contractions of the chromatophore, causing the change of color. Girod, however, considers the fibres to be of connective nature, motion being produced by the pigment cell itself. The author decides for the muscular character. During the contraction of the cell the fibres are thinner than during the expansion stage. The nuclei of the radial fibres, which lie adjacent to the pigment cell assume an elongate radial position during contraction of the pigment cell. In the extreme expansion stage the nuclei become tangential, in intermediate stages the form is globular.

The radial fibres receive no nerves. Joubin has traced nerves to the chromatophores by means of methyl blue *intra vitam*. The chromatophores seem to function only for a certain length of time and then degenerate and are substituted for by new ones.

According to our author the nerve fibre fuses directly with the chromatophore without the formation of any sort of end-organ. The nervous connection takes places after the young chromatophore has partially developed. It will be seen from the above that either these chromatophores differ *toto cœlo* from those of vertebrates (this Journal, Dec., 1893, p. clix) or the present study needs revision.

Annual of the Universal Medical Sciences.[1]

The sixth issue of this standard and well-nigh indispensable aid to the busy physician, surpasses in excellence its predecessors. It has been enlarged, broadened in scope and improved in other ways. The editor, who is now residing in Paris, is in a position to come more closely in touch with current progress on the Continent, without however losing anything in the thoroughness with which American topics are treated. The list of foreign associates has been greatly enlarged, and the subscribers are to be congratulated on the great improvement noticeable in these departments. Some of the more important articles on the Nervous System only can be mentioned. "Diseases of the Brain," by Dr. Landon Carter Gray, of New York, "Diseases of the Spinal Cord," by Dr. H. Obersteiner, of Vienna, "Peripheral Nervous Diseases, Muscular Distrophies, and General Neuroses," by Drs. Bourneville and Sollier, of Paris, "Mental Diseases." by Dr. Geo. H. Rohé, Catonsville, Md., "Inebriety, Morphinism and Kindred Diseases," by Dr. Norman Kerr, London, "Surgery of the Brain,

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[1]CHARLES E. SAJOUS, Editor-in-Chief. Published by the F. A. Davis Co., Philadelphia.

Spinal Cord and Nerves," by Dr. Lewis S. Pilcher, of Brooklyn, and Dr. Samuel Lloyd, of New York, "Traumatic Neuroses," by Dr. J. A. Booth, New York.

Lesions of the Cerebellum in Monkeys.[1]

The most noteworthy features of complete extirpation of the cerebellum were the extraordinary disturbances of station and locomotion, and the long-continued and apparently persistent unsteadiness of the trunk and limbs on muscular effort. There were noted, also, from the first, absence of tonic flexion or contraction of the limbs; retention of great and, apparently, unimpaired muscular strength, as evidenced by the firmness of the grasp of the hands and feet, and the agility in climbing; and the presence, with ultimate exaggeration, of the knee-jerks. There was no impairment of the general or special sensibility, or disturbance of the organic functions.

The symptoms observed after extirpation of a lateral lobe, after the first tumultuous disturbance of equilibrium had passed off, were similar to those observed after complete extirpation, with the important difference that they were confined to the limbs on the side of lesion. Except in one case, where it was only present to a slight extent, there was no impulsive tendency to rotation.

Extirpation of the middle lobe, including antero-posterior division, produced, in general, the same symptoms as were observed in connexion with removal of the whole organ and of the lateral lobe, but they did not affect one side more than the other, and were more pronounced in the head and trunk than in the limbs.

The symptoms following section of the cerebellar peduncles were similar to those occurring after removal of the lateral lobe, the chief difference being the greater tendency to roll round the longitudinal axis towards the side of lesion, whichever peduncle was cut.

Destruction of the clavate and cuneate nuclei caused temporary disturbances of attitude and gait, but there was no affection of cutaneous sensibility.

The degenerations following removal of the lateral lobe of the cerebellum, or section of the superior peduncle, showed that this structure contains an efferent tract to the opposite red nucleus and op-

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[1]A Record of Experiments illustrative of the Symptomatology and Degenerations following Lesions of the Cerebellum and its Peduncles and related Structure in Monkeys. *Proc. Roy. Soc.*, LIV, 330.

DAVID FERRIER and W. ALDEN TURNER.

tic thalamus, and an afferent tract, which appears to be the cerebellar termination of the antero-lateral ascending tract of Gowers.

Lateral lobe extirpation, or section of the middle peduncle, was followed by diminution of the transverse fibres of the pons Varolii on the side of the lesion, and atrophy of the cells of the nucleus pontis on the opposite side.

Lateral lobe extirpation, or section of the inferior peduncle, demonstrated the existence of an efferent tract to the opposite inferior olivary body, and of an afferent tract to the cortex, chiefly of the lateral lobe.

Extirpation of the middle lobe occasioned no degeneration in the superior, middle, or inferior cerebellar peduncles, but was followed by degeneration and sclerosis of the tract which passes from the vermiform process to Deiters' nucleus—the "direct sensory cerebellar tract" of Edinger.

We were unable to confirm Marchi's statements as to the existence of a direct efferent cerebellar tract in the spinal cord, or of degeneration in the anterior nerve roots, mesial fillet, or posterior longitudinal bundles, after cerebellar extirpation.

In two cases of lateral lobe extirpation, however, we obtained degeneration in the anterior and lateral columns of the spinal cord respectively, in the position indicated by Marchi. In the case, however, in which there was a marginal degeneration in the anterior column, the nucleus of Deiters, on the same side, was implicated; while, in that in which degeneration in the lateral column was present, there was a lesion of the tegment of the pons, involving the nucleus of the lateral fillet. The same degeneration was induced by lesions specially made in the lateral fillet.

Destruction of the clavate and cuneate nuclei was followed by degeneration, on the one hand, through the restiform body into the cerebellum; and, on the other hand, through the internal and middle arcuate fibres to the opposite interolivary layer and mesial fillet. This latter structure was traced to the anterior quadrigeminal bodies and optic thalamus.

Owing to lesion in some of the experiments of the roots of the 5th cranial nerve, we were led to make special investigations on its central connexions. Degeneration and sclerosis of the so-called "ascending root" was traced as far as the 2d cervical nerve, after section of the sensory division; and atrophy of the so-called "descending root" was observed after section of the motor division. We were unable to confirm the existence of a direct cerebellar root to this nerve.

The Development of the Head of Ammocoetes planeri.[1]

Professor Kupffer pursues the subjects treated in his previous papers and is obviously much influenced by the conceptions derived from his studies in the embryology of the sturgeon. This author never fails to prove suggestive even where his arguments may seem unconvincing.

The present paper begins upon the basis of the statement that, in the sturgeon and chick, the axis of the brain tube terminates between the olfactory tubers in an azygos plate of the epidermis which the author homologizes with the olfactory organ of the Monorhina. This is "a terminally situate sensory organ." A series of longitudinal sections at different stages is discussed and brought, as far as possible, into harmony with the sturgeon series. An unpaired thickening of the epidermis at the dorsal portion of the truncated cephalic extermity of the (primarily solid) nerve tube is the olfactory plate. The hypophysis at this stage is a slight depression at the ventro-cephalic angle of the tube. At the eighth day the olfactory plate has become depressed producing a beak-like angle of the nerve tube at its dorsal end which is identified as the olfactorius impár. The brain at this period is divided into three segments.

Larvæ 4 mm. long have the free rounded end of the olf. impar retracted from the olfactory organ but a short fibrous cord connects the two points. This cord Kupffer regards as a transient olfactory nerve.

These studies prove (what was *a priori* to be expected) that the so-called anterior epiphysis is homologous with the paraphysis of other vertebrates. It arises at the caudal limit of the poorly-differentiated prosencephalon.

When Ammocoetes becomes 7 mm. long a retrograde metamorphosis of the brain begins, exhibiting itself in the decrease of the cerebellum, and of the commissures. The olfactorius impar and vesicle of the prosencephalon have already disappeared.

Kupffer discovers that there is a special decussation of fibres cephalad of the supracommissure without recalling that such a double commissural system has been described by C. L. Herrick in a large number of different vertebrates. The statement that the fibres after decussation apply themselves externally on the paraphysis should be verified in various stages. The author corrects Studnicka's error in deriving the "parapineal organ" or paraphysis from the dienceph-

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[1]KUPFFER, C. V. Studien zur vergleichenden Entwickelungsgeschicte der Kopfes der Kranioten, 2. J. F. Lehmann Munich-Leipzig 1894. 10 marks.

alon. The azygos character of the prosencephalon obscures relations somewhat.

A second part of the paper treats of the preoral digestive tract and the mesoderm of the head into which our limits will not permit us to go. The author concludes, however, that in the ontogeny of the Craniates there has been a retrograde metamorphosis in the ventral region of the head, as a result of which the original cephalic part of the digestive tract has been lost. The mouth of Craniates is not terminal but is derived from a point ventrad and caudad of the front. The hypophysis he regards as the original mouth, *paleostoma*, while the functional mouth is a *neostoma*.

The trabeculæ cranii in Ammocetes are related to the hypophysis as the inferior maxillaries are to the mouth.

The last section of the paper is devoted to the development of the cranial nerves and as it requires fuller analysis than can now be given it and forms but the introduction to the "study" next to appear, it may be reviewed in connection with the latter. The clear and easy style of the author and the elegant work of the publisher combine to produce a very acceptable series.

Embryology of Selachians.[1]

These observations form the principal part of the descriptive portion of the author's work recently published in Russian on the development of vertebrates.

I. *Origin of the Nerves.*

1. Separation of the nerve-tube from the ectoderm. The author here adduces evidence to show that the whole central and peripheral nervous system springs from a single proton (anlage).

2. Primitive differentiation of the general proton of the peripheral nervous system. By this proton we understand that embryonic structure which gives rise to spinal ganglia, dorsal roots, and peripheral nerve fibres. The differentiation of the ganglionic layer from the dorsal wall of the nerve tube marks the first step in the development of the peripheral system; the dismemberment of this layer, the second. In Raja there is no trace of this layer up to the closing of the nerve-tube. Then a less compact arrangement of the walls of the tube in the parietal region of the head forms the first step in this differentiation. The epidermal groove is still well marked, but its walls

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[1]Mitrophanow, P. Etude Embryogènique sur Sélaciens, *Arch. de Zool. Exp. et Gen.* 3d Series, I, 1893.

are completely closed and separated from the nervous elements. In the ganglion layer karyokinesis is in progress and toward the periphery the cells show branched processes. While this differentiation is continued caudad, the cephalic part of this proton, which has been already formed, begins to atrophy after having previously separated into the protons of the ganglia of the first cranial nerves. The whole proton is now plainly differentiated into three parts; the first is the proton of the cranial nerves in front of the trigeminus, the second of the trigeminus, the third subsequently separates into the acustico-facialis and the glossopharyngeo-vagus systems. The successive positions of these parts, their union with the nerve-tube not only dorsally but laterally and the evidence of active karyokinesis in the latter, all go to show that the ganglia are developed from the nerve-tube. The existence of mitotic figures in the peripheral part of the proton shows in turn that these elements are now morphologically separate and that they continue to multiply independently.

3. The formation of the embryonic nervous groups and their ganglia. Five such groups are distinguished. (1). Those cephalad of the trigeminus. This group is composed a small number of elements which are hard to separate from the next group. At its maximum development it consists of a loose group of cells above the optic vesicles. The principal outgrowth of this proton passes behind the eye, and there forms a large oval mass which then degenerates, after having entered into relations with that part of the trigeminus proton from which originates the ciliary ganglion. This connection, however, is considered secondary and unimportant. The whole proton of this first group subsequently disappears and the author considers that it has only a transitory significance. While the observations here expressed differ in several more or less essential points from those recently published by Dohrn, Baird, Kupffer and others, yet there are certain broad lines of agreement among them which are very gratifying. Kupffer's recent papers, especially, should be read in this connection.

(2). The Trigeminus group. It is in this locus that the peripheral system first appears. In Raja clavata of 12 days this proton appears as a large plate symmetrically covering the mid-region of the brain. As development proceeds it becomes more sharply separated from the neighboring groups. At 20 days the mandibular and ophthalmic rami are indicated. As the fourth ventricle expands and the medulla becomes differentiated from the mid-brain, the trigeminus proton is carried laterad and caudad, still retaining, however, its primitive connection with the mid-brain by means of a narrow mass of cells, the anterior root. The posterior and stronger root has meanwhile become attached to the medulla. The anterior root now suffers regressive development until at 26 days nothing remains but a group of cells in the wall of the mid-brain. The discussion of the Trigeminus group is summarized as follows:

1). The general proton divides proximally into two roots, of which the posterior has the more complicated and important development.

2). The posterior root produces mandibular and ophthalmic projections, from the former of which develop the *ramus mandibularis* and later the *ramus maxillaris* from the latter the *ramus ophthalmicus profundus.*

3). In the central part and in more intimate connection with the mandibular projection the *Gasserian ganglion* develops, and in the peripheral part of the ophthalmic projection there develops the *ciliary ganglion* (Mesencephalic).

4). The anterior root undergoes a regressive alteration; its distal part produces, in connection with the central part of the proton the *ramus ophthalmicus superficialis portio trigemini;* its proximal end, becoming detached from the distal part, remains some time as a transitory ganglion, which, according to Froriep, takes part in the formation of the *nervus trochlearis*, although the latter may be genetically related to the *ramus ophthalmicus superficialis*, *portio trigemini*, as stated by Miss J. Platt.

5). From the ciliary ganglion there separates a ganglionic mass which may be considered as the *ganglion oculomotorii* and which produces the primitive *nervus oculomotorius.*

These last points are sufficiently striking; and if the fact be finally corroborated that the oculomotor and trochlearis nerves are centripetal in origin, it is certainly true, as the author states, that these nerves must hereafter be studied from an entirely new point of view. Over ten years ago VanWihje insisted that the mixed cranial nerves have no elements analogous to the motor roots of the spinal nerves; but that the pure motor nerves passing to the eye-muscles are the only cranial nerves passing to the muscles of the somites, and therefore the only ones homodynamous with motor spinal roots. If the facts here adduced are true it would seem that even this comparison is inadmissible and the difficulty of comparing cranial and spinal nerves is still more increased.

(3). The Facialis group.

From this proton arise, besides the *facial* and *auditory* nerves, the *ramus ophthalmicus superficialis, portio facilis* and the *ramus buccalis.* The steps in the development are as follows :

1). At first it is represented by a triangular plate above the hyoid arch, which is originally connected both with the trigeminus and with the vagus protons, though the connection with the former is early lost.

2). Simultaneous with the formation of the auditory vesicle it breaks up into auditory and facial divisions. The auditory division enters into intimate contact with the base of the auditory vesicle and the facial division, at the same time, with the epidermis above the hyoid arch and later above the superior edge of the first visceral cleft.

3). The structure so far is exclusively cellular; its connection with the brain is by simple contact; fibres pass into the brain later.

4). Simultaneously with the latter process the facial division separates into *ramus ophthalmicus superficialis* and *ramus buccalis.*

5). The *nervus acusticus, ramus hyoideus, ramus buccalis,* and *ramus ophthalmicus superficialis, portio facialis,* then constitute four indepent branches, each of which has in its central part a ganglion. These united ganglia form a sort of four-pointed star.

(4). The Vagus group.

1). It appears first immediately behind the facialis group and in intimate connection with it.

2). Its cephalic border reaches first the branchial region and prolongations are successively detached from it, as the visceral sacs are forming, to the third, fourth, etc., branchial arches. The first prolongation separates before the others and represents the primitive glosso-pharyngeus. Meanwhile the caudal border gives rise to the proton of the spinal ganglia (bandelette ganglionnaire).

3). Upon the formation of the fourth pair of visceral sacs and the appearance of the somites in the occipital region, the proton of the vagus proper is quite separate cephalad from that of the glosso-pharyngeus, except at the central part; along the back it is prolonged into the proton of the spinal nerves; below at the level of the notochord it becomes finer and enlarges again lower down in the branchial region.

4). Subsequently we observe the gradual reduction of the central part next to the brain until only a commissure remains. At the same time the peripheral part develops into the branchial rami and their ganglia and establishes connection with the branchial epidermal thickenings.

5). The connection, primitively broken, between the proton and the brain is again established, on the one hand by the formation of numerous small roots in the whole region where the proton is adjacent to the brain, even in the region of the commissure; on the other hand by the development in front of the proton of a general common rod whose fibres pass into the brain considerably cephalad of the others. At the same time the proton differentiates caudad into lateral nerve and intestinal nerve (pneumo-gastric).

6). The general cephalic root above mentioned is related chiefly to the system of the lateral nerve. Springing from the brain nearest to the facialis group, it descends behind the auditory vesicle into the branchial region, contributing in its passage some fibres to the glosso-pharyngeus and branchial rami of the vagus; these fibres serve for the formation of the little suprabranchial rami which become attached to parts of the branchial epidermal thickening; they subsequently form the organs of the lateral line. The last of these suprabranchial rami is especially developed to form the lateral nerve proper.

For further theoretical discussion of these observations the author refers to his work published in the transactions of the International Zoölogical Congress at Moscow, 1892.

(5). The spinal nerves are not discussed in this paper.

II. *Development of the Organs of the Lateral Line.*

After a detailed description of the mode and order of the development of the mucus canals from the epidermis and of their innervation, the author presents the following summary:

1. At the beginning there is along the side of the head a general auditory and branchial thickening.

2. Its middle part, nearest the dorsal groove separates above the hyoid arch to form the auditory lamella. [This is another link in the chain of evidence which has been so rapidly strengthened of late, showing the genetic relationship between the ear and the lateral line organs.]

3. While the latter is transforming into the auditory pit parts of the hyoid and branchial arches separate from the branchial thickening, one after the other successively from before backwards.

4. At the time of the transformation of the auditory pit into the auditory vesicle, aside from the separation from the branchial thickening just mentioned, there is another from the anterior part, above the first visceral cleft (spiraculum), and another from the lateral part behind the auditory vesicle and above the branchial region. The subsequent development of each of these parts is intimately associated with that of the nerves with which they enter into close relations.

5. The anterior part, separated from the thickening of the hyoid

arch, is divided into two epidermal rods which passing forward surround the eye. They form later the supra- and infra-orbital mucus canals.

6. In connection with the general thickening of the anterior and exterior surface of the hyoid arch, there is found at its inferior end a thickening below the cleft on the mandibular arch, which in part gives rise to the mandibular part of the lateral organs.

7. Each branchial thickening later undergoes a further differentiation. At the place where the ganglion of the corresponding nerve attaches to it, along the superior and posterior edges of the visceral cleft, a branchial organ is formed; six on each side of the body.

8. Above each branchial organ there separates, in the form of a rod, from the superior part of the branchial thickening at the level of the notocord, the part destined for the lateral organs. Their formation is simultaneous with the development of the little rami of the suprabranchial nerves.

9. The lateral part which at first separates imperfectly gives rise to the lateral line of the trunk. Three protons, scarcely distinct, of the lateral organs corresponding to the second, third, etc. branches of the vagus nerve constitute its proximal part.

10. Thus the system of the lateral organs of Selachiens is primitively composed of the following separate parts: of the protons of the mucus canals, (*a*) supraorbital, (*b*) infraorbital, and (*c*) mandibular; of the portions above the suprabranchial rami, (*d*) of the *ramus buccalis* (*ramus oticus*), (*e*) of the *glosso-pharyngeus*, (*f*) of the first branch of the *vagus*—the two latter forming the parietal canals,—(*g*) of the second branchial ramus of the vagus; (*h*) finally of the proton of the lateral line properly so-called.

After a review of the relations of the lateral organs in all of the Ichthyopsida the author concludes that in all members of this group a part of the general sensory epidermal thickening is split off to form the auditory and branchial thickening which subsequently develops into the organ of hearing, the branchial and lateral organs, very much as described above for Selachians. This conclusion is very important for the definition of the metameric significance of the lateral organs. For obviously these facts oppose the doctrine that the lateral organs originate in a metameric manner. The metameric arrangement is purely secondary, as a result of preexisting arrangements. These organs therefore cannot be used as a criterion to define the primitive vertebrate metamerism. C. J. H.

Ectodermal Elements in Cranial Ganglia.[1]

Miss Platt call attention to the relations found in the ganglia of Necturus between mesoderm and ectoderm. She divides the mesoderm into mesectoderm and mesentoderm, according as it is derived from one or the other of the two primitive layers. Cells arising from the ectoderm and entoderm respectively are differentiated from each other until a late stage of embryonic development by the yolk globules which they contain. "I have not observed the migration of cells from the brain into the ganglia except through the neural crest, and if such migrations occur at an early stage they are not common. I have moreover seen some of the original mesectoderm cells which take part in the formation of Gasserian ganglion 'spin' fibres to muscle cells lying in the mandibular mesentoderm. These are undoubtedly motor fibres 'spun' from cells that have not migrated from the brain, unless through the neural crest. Connecting this fact with observations made by Froriep and myself on the development of the trochlearis in Selachians, I am inclined to think that before the great motor and sensory tracts of the central nervous system are established individual peripheral cells may complete in themselves a reflex arc, either as an ancestral characteristic repeated in embryonic development or as an advantageous larval acquisition."

The Optic Vesicles of Elasmobranchs and their Serial Relation to Other Structures on the Cephalic Plate.[2]

Mr. Locy states that the involutions that are to give rise to the optic vesicles appear at a very early stage. As soon as the cephalic plate has been formed, by one expansion of the anterior end of the embryo, two faint circular depressions are to be seen upon its extreme anterior surface. These depressions grow deeper and run together in the middle line, and the continuous infolding produced in this way divides the cephalic plate into an anterior depressed region, and a posterior elevated region. The infolding gives rise, also, to infundibulum. The optic vesicles, which are started near the median line,. grow outwards laterally, and come to occupy the lateral parts of the depressed region, but as the infolding forming it does not extend entirely across the cephalic plate, the optic vesicles do not reach the margin of the medulary folds. When distinctly formed, the optic

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[1]JULIA B. PLATT. Ontogenetic Differentiations of the Ectoderm in Necturus. *Anat. Anz.* IX, 1, 2. Oct. 1893.

[2]LOCY, W. A. *Journ. Morphology*, IX, 1.

vesicles are circular in outline, concave from within, and form rounded elevations on the outside where the cups come in contact with the outer layer of the epiblast. The optic vesicles are clearly outlined in Squalus acanthias before the medullary groove is fairly established. Related to these are other depressions on the cephalic plate. These are circular depressions formed in the same manner as the optic vesicles but behind them as if the process of eye-formation were repeating itself serially. These the author calls accessory optic vesicles. If the views expressed are true we have a multiple-eyed condition in the embryos of these animals and the author employs these facts as evidence of the origin of eyes from segmental organs. The anterior accessory vesicles the author subsequently identifies as the protons of the pineal outgrowths which are thus rendered homodynamous with the lateral eyes. We await with interest more substantial evidence than that afforded by the very unsatisfactory diagrams which accompany the paper. Certainly in matters of this sort we may hope for the confirmation of serial sections.

The Psychological Review.

In accordance with the announcement made some time since and which has awakened much interest, the first issue of this Journal appears promptly with the new year.

Professors J. M. Cattell of Columbia and J. M. Baldwin of Princeton issue the periodical with the active coöperation of a very able corps of associates from America, England, Germany and France. That the appearance and make up is all that could be desired goes without saying.

It is perhaps inevitable in the present transitional stage of psychology in America, when almost all our better colleges offer some experimental work, which is dominated largely by the old ideals, that the product in the form of printed results shall have a sketchy and unsatisfactory character. Such a periodical as the present one should do much to set high ideals for such work. This place has been worthily filled for some time by the American Journal of Psychology, though the difficulties under which it has labored made themselves manifest at times.

It is hardly complimentary to American intellectual independence to note that we are quite unwilling to accredit or assist any attempt originating here until the verdict of certain *authorities* abroad has been heard.

The present issue is chiefly noteworthy in its promise for the future.

Among the Review Departments that on Neurology is notably weak. Such a department should either give us the recent literature or a reasonably complete topical discussion. In this case nervous histology is selected but the titles and facts noted scarcely suggest the present status of the subject. The attempt to introduce a new nomenclature for the neuron and its parts [Schäfer's] just as terms are gaining general acceptance is to be deprecated.

Optical Time-Content.

Professor Münsterberg and Mr. A. R. T. Wylie have investigated the influence of different optical stimuli upon the time estimates. Different colors and patterns were so placed upon the Ludwig Kymograph that they moved past a screen perforated for the eye of the observer at a uniform rate. The subject estimates the relative time required for the various color patterns to pass. The result corresponds with that reached with auditory stimuli. Irrespective of the number of presentations, the times appear shorter the more the optical time content attracts the attention, and thus diverts it from the observation of the accompanying subjective phenomena produced by bodily changes.

Memory.

Professor Münsterberg reports in the first number of the Psychological Review the results of experiments carried on with the assistance of J. Bigham. The work was intended to determine whether the different senses act at the same time independently, help, or hinder each other.

Under suitable precautions a series of 10 or 20 visible colors or numbers or audible colors [names] and numbers or symmetrical combinations of both were presented and the observer after 2 seconds observation was required to reproduce the series with cards carrying the colors and numbers. The results may be briefly summarized thus: When two senses act together in recollection, they hinder each other. When isolated, the visual memory surpasses by far the aural; when combined the aural excels the visual. The memory is impeded by a closer combination of different contents. A series of presentations offered to two senses at the same time is much more easily reproduced than if given only to sight or only to hearing.

It may be added that the above line of experimentation would be rendered much more instructive for pedagogic purposes if a comparison could be made of the effect of imitative reproduction as by writing or drawing the object presented.

The Intensifying Effect of Attention.

Professor Münsterberg and Mr. N. Kozaki describe experimental studies which show that all stimuli appear relatively less when the attention is from the outset directed to them. Intensities are estimated relatively. Just as weights are underestimated when by reason of a preparatory innervation we lift them with too great a tension of the muscles, so if the sensations of tension in the sense organ are previously strengthened by expectant attention the stimulus will appear weaker than it would if the stimulus itself were to arouse reflexly all the corresponding muscular tensions.

Rhythm.[1]

This article is prefaced by an introduction on Rhythm in general. "The pleasure that individuals take in the rhythmic flow of words and sounds, has been ascribed to the "*Unifying activity of the feelings*" by one author; to the "*Sense of order*" by another; and to "*The feelings of equality*" by still another. The author of this paper remarks that "to regard rhythm as the manifestation or form of the most fundamental activity of the mind seems a clearer view than to regard it as the ultimate fact itself." He goes on to sum up briefly some general conclusions which are sufficiently suggested by the following sub-heads. "Rhythms in Nature," "Physiological Rhythms," "Attention and Periodicity," "Rhythmic Speech," "Time Relations," "Intensity of Sounds," "Qualities of Sound," "Emotional Effects of Music on Savages and Children," "Place of Rhythm in Music and Poetry," "Æsthetic Forms," "Philosophies of Verse." We then come to the more important *experimental* work.

"The first and most important object of these experiments was to determine what the mind did with a series of simple auditory impressions in which there was absolutely no change of intensity, pitch, quality or time-interval. Regular variations with respect to the intensity or time-interval of the sounds in this series, which will be called a rhythmic series, were then to be tried separately and together, with the purpose of determining what values these properties of sound have in forming a rhythmical series."

For this purpose a machine was devised which should furnish this constant repetition of a sound of the desired pitch, intensity and duration. A break at regular intervals in the primary circuit of an

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[1]THADDEUS L. BOLTON, Demonstrator and Fellow in Psychology, Clark University. *Amer. Journal of Psychology*, Jan., 1894.

electric current, when the secondary circuit is closed, was all that was necessary to furnish the required series of auditory impressions with which the investigation might begin. A chronograph after the pattern devised by Wundt furnished the power. Upon a drum-shaft were hung five arms each adjusted by a set-screw, these so patterned that they, in the course of their revolution, pressed upon given keys for a definite length of time. This established the circuit. By making the number of degrees between the arms on the drum-shaft different, a difference in time-interval between the clicks was produced. The description of this apparatus and any detailed account of the result of experiments upon some 50 or more different subjects can not be added here. The first point in the records to which attention is called is the *rhythmical grouping* of the sounds. The subjective grouping was the same in every case—accomplished by accentuating regularly certain sounds more than others. The weaker or less accented sounds seem to run together with the stronger, and to form organic groups which are separated from one another by intervals which are apparently longer than the interval which separates the individual clicks. Some of the subjects associated the sounds to the continual dropping of water, the puffs of a locomotive. Some kept time by an involuntary nodding of the head and beating time with the finger. Nearly all the subjects had had some musical education. The 2-group and 4-group were formed most readily, while a 3-group or a 5-group was usually formed with difficulty and only on suggestion. With fast rates, the pulse acted as a suggestion. All clicks falling between two heart-beats were grouped together, the click coming nearest in time to the heart-beat being accented. Most subjects felt themselves impelled by an irresistible force to make muscular movements of some sort accompanying the rhythms. The author on this latter point agrees with Ribot that "every intellectual state is accompanied by physical manifestations." "No thought without expression." If the length of the group corresponds to the normal wave of attention, the grouping gives rise to a feeling of satisfaction and repose. A few general principles may be stated: "A given number of auditory impressions within certain limits, when presented in such a way that there is a kind of subordination among them with respect either to time, intensity, pitch or quality, or with respect to any two or more of these properties, always stands as a unit in consciousness. The conscious state accompanying each wave of attention grasps together or unifies all the impressions that fall within the temporal period of a wave. The essential conditions of forming such a unity among sounds is a regular temporal sequence within certain limits, and perfect uniformity in intensity, pitch and quality.

The conception of a rhythm demands a perfectly regular sequence of impressions within the limits of about 1.0 sec and 0.1 sec. A member of the sequence may contain one or more simple impressions. If there are a number of impressions, they may stand in any order of arrangement, or even in a state of confusion, but each member of the sequence must be exactly the same in the arrangements of its elements. H. H. BAWDEN.

Conditions of Mental Activity.[1]

This paper gives the results of two lines of investigation carried on at Clark University.

Part 1 gives an account of experiments upon daily variations in the rapidity of the repetition of old and of the formation of new associations, with a view to determine whether there is a natural rhythm of mental activity or not. As showing the constant daily variations, numerous tables of observations are given, indicating the relative speed with which cards can be sorted, figures can be added and multiplied, nonsense syllables memorized, etc. at various intervals through the day.

Among the results may be mentioned the following. The subjects, whose records cover the entire waking period have a well marked periodicity of mental activity. There is, however, no *general* type of daily rhythm, and individual differences of the most striking sort occur. The same influences have different effects upon different individuals. Under the influence of fatigue, rest, and physical exercise, the processes studied vary in the same direction. Statistical investigations show that those who are engaged in mental work have generally observed a daily rhythm of power. Actual measurements and statistics of opinions both show that in a certain number of cases there will be persons whose maximum activity comes at almost any given hour of the waking period. The rhythm of activity may or may not correspond with the actual energy at the person's disposal. Other things being equal, the total amount which can be accomplished decreases as the interval since sleep increases, but the rate of work may be most rapid a little before retiring. While most persons thus recognize the existence of a daily periodicity of activity, which is of

[1]BERGSTROEM, J. A. An Experimental Study of Some of the Conditions of Mental Activity. *Am. Jour. af Psychology*, VI, 2, Jan., 94.

great importance for the quality and quantity of work they can do, this does not conform to any general type, and is, therefore, not an inherited modification of the nervous system. The daily rhythm is the result of a number of stimulating and depressing causes, whose influence habit tends to fix upon the system. These very suggestive observations are followed by a critical discussion of fatigue.

Part II deals with the retardation of memory by means of the interference of associations and continues some observations reported in the *American Journal of Psychology*, Vol. V, No. 3. Two packs of cards with the same words or symbols were sorted successively into different positions. On the average 65 seconds were required for the first pack, but 85 for the second, if this was sorted immediately afterwards. The difference is called the interference time since it is due to conflict of associations and not to fatigue. The time for sorting the cards decreased considerably with practice, but the amount of interference did not. The latter however decreased as the interval between the two acts was increased, at first very rapidly, then more slowly.

These tables of observations suggest several important pedagogical hints in the training of the memory and serve to explain many cases in which errors of computation, translation, etc. may remain unperceived even after hours of search, but which may flash into the mind in a moment after a few hours of rest. The author concludes: "As a class, these facts have usually been explained by some theory of unconscious cerebration, or they have been attributed to the summation of stimuli, or to rest.

"That these phenomena are due to a summation of stimuli which gradually gathers sufficient strength to break through the nervous resistance into the correct association, seems impossible, since every nervous excitement diminishes in intensity if left to itself, and the quickest and most striking results are usually obtained by putting the problem entirely out of mind for a while.

"Fatigue and rest have, as is well known, a considerable influence upon the rate of mental work, but these cases seem to occur, just as in the memory work, when there is no fatigue present. The unreliable and often fantastic character of mental processes in the indirect field of consciousness, in revery, and in dreams, the stupidity of secondary consciousness together with the absence of fatigue from this imagined unconscious cerebration, makes it probable that it is of little importance, and that conscious attention is the forge in which most, if not all, valuable mental work is done. . . . . . ."

"Sensorial" and "Muscular" Reactions.[1]

These experiments upon the time difference between the sensorial and muscular forms of reactions, carried on with the Hipp Chronoscope (new pattern), lead the authors to the following conclusions:

(1) That the new pattern chronoscope requires a thorough testing before its times can be accepted as of absolute value.

(2) That the sensorial-muscular difference is not, as Dessoir thinks, a matter of the form of the reaction-instrument. We have obtained the difference with three reaction-keys, involving diversity of muscular action. It averages, in these cases, .090 sec., .1055 sec., and .1493 sec.

(3) That we may confirm the view that not every person is able to function as a reaction-subject. Rather is there required for the work a special kind of mental disposition or *Anlage.* If the volitional temperament is unfavorable, practice will have no effect in determining the two types of reaction-time; if favorable, Lange's distinction holds even of the first practice-experiments.

Experimental Contribution to Memory Study.[2]

This paper is based upon the well-known work of Professor Ebbinghaus and proposes an amplification and verification of the methods employed by the latter. The operative methods were greatly improved by the fact that two persons coöperated, one as subject, the other as director and by the device by which the syllables to be memorized were exposed to view through a slot in a screen by the rotation of a uniformly moving Kymograph thus avoiding the possibility of association in advance. The most elaborate precautions were taken to avoid any subjective choice in the selection of the sequence of sylables, while providing for the alliterative, rhyming and thought-suggesting collocations very perfectly. In the second part of the paper [Hefte 4-5.] is an extended discussion of the results which is difficult to summarize though it stands in great need of condensation.

1. The influence of rhythmical accent is of the utmost importance in learning a series of nonsense syllables. In the method pursued it was found almost impossible to learn a series of twelve syl-

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[1]HILL, A. R. and WATANABE, R. Minor studies from the Psychological Laboratory of Cornell University, *Am. Jour. of Physchology*, VI, 2, Jan., 1894.

[2]MULLER AND SCHUMANN. Experimentelle Beiträge zur Untersuchung des Gedächnisses. *Zeitschr. f. Psychologie und Physiologie der Sinnesorgane*, VI, 2, 3, Nov., 1893.

lables without rhythm. As the German abounds in words with accent on the first syllable the rhythm most affected is trochaic.

2. The tracing of the respiratory curve upon a tracing of the syllables shows that the limits of respiration determine the number of syllables linked together.

3. There seems never to be a uniform distribuion of attention upon the entire series of syllables but the authors think there is a certain amount of attention apportioned, as it were, to the whole series which may then be very unequally distributed within it. The fact that the syllables which are pronounced with difficulty are not most clearly recalled is explained by the fact that though more attention is given to the act of enunciation, less is given to the synthesis of sounds resulting.

4. It was found that the vowel sounds are remembered better than consonants. This is in harmony with Möli's observations on Aphasia and Paraphasia (patients often giving only the vowel correctly.) When this occurs it proves that the memory is based on auditory impressions. In the case of artists the recollection is primarily visual.

5. The tendency to motor or sensi-motor accompaniments of the act of learning were greater when attending to the visual than to the spoken series.

6. Associative connection of syllables was found of great importance in reproducing them and a number of self-intelligible variations of this influence noted.

7. Practice is found, of course, to improve the power of memorizing.

Only a few points can be referred to even thus briefly. Only those who have conducted such researches can appreciate the patience required in an investigation which, like this, extended through several years and yet involved the most monotonous uniformity of repetition. Even our great admiration for such patience and effort cannot wholly compensate for the apparent meagerness of the results. Yet it is only by such attempts that pedagogy will acquire a scientific basis.

Inverted Vision in the Savage.

Dr. F. A. Cook, who was ethnologist of the Peary expedition to Greenland, made the interesting observation that the natives habitually look at pictures upside down. He asked them to draw a polar bear. To this they readily acceded, but drew the figure inverted. On his return to Laborador, Dr. Cook observed the same characteristic of vision, to less extent, among the mountaineer Indians. It is a matter of common observation that young children often exhibit a tendency to look at pictures reversed. The explanation offered by Dr. Cook that the image is more easily interpreted by reason of the reversion of the image upon the retina is obviously untenable, for the same thing would then apply to natural objects. A tentative explanation may be offered as follows: In the child the position of the image upon the retina is an absolutely indifferent matter, and is interpreted by experience as a result of association. To the child, as to the savage, the picture is, in a manner, an unoriented image, and sustains no necessary relation to his own person (the only absolute standard). When then orientation is attempted it is natural that objects which stand highest in the field of view and thus nearest the head should be placed in such a position as to be actually nearest the observer. This produces a reversed position which is only corrected when the person comes to make a direct comparison of the pictured with the real image.

The Origin of Right-handedness.[1]

Professor Baldwin has carried out some very interesting experiments respecting the causes which lead to the development of one side in advance of the other.

It was found in the case of the child experimented upon that during the fifth to ninth months of her life there was no appreciable preference for the right hand when an object is placed within easy reach and equally accessible to both hands. When, however, the object was placed so far away as to be out of easy reach the right hand was almost uniformly employed; thus, when the object was twelve inches away the right hand was used twenty-nine times and the left only five times while severer distance tests called out the right hand uniformly.

Again if the object were exhibited at one side of the median line the result was the same except that the right hand was called more strongly into action. The use of colored objects proven to be especially attractive to the child had the same effect. It should be noticed that the tendency to use both hands in grasping at near objects is twice as great as that to use either separately and where one hand is preferred the other tends to symmetrically accompany it. A survey of correlated facts leads to the view that there is a fundamental connection between the rise of speech and the rise of right-handedness.

[1]BALDWIN, J. M. *Pop. Science Monthly*, XLIV, 5.

New unsymmetrical functions give a differential or two-fold organic development, the great instance of which is found in the cerebral hemispheres. New symmetrical or unilateral functions find their counterpart each in one of three kinds of nervous adaptation: (*a*) Co-ordination of the hemispheres in a single function—i. e., functions which are crippled if either hemisphere is damaged; (*b*) Co-ordination of particular functions in each hemisphere—i. e., functions which are not crippled unless both hemispheres are damaged; and (*c*) Co-ordination of particular functions in one hemisphere only—i. e., functions which are crippled if one selected hemisphere is damaged. Both speech and the right-handed function come under the last head. These functions have in common their *expressive* character. "Upon this view it is easy to hold that right-handedness is a form of expressive differentiation of movement, and that it preceded speech, which is a further and more complex form of differentiation and adaptation."

In the instances reported the following facts support the theory: 1. Right-handedness arose before speech. 2. Imitation by the hand of movements seen to arise before articulate imitations of sounds heard. 3. Characteristic differences in children in respect to their general mobility of arm and hand, manual skill, etc., extend also to speech. Musical ability is also associated with speech ability. As to the origin of the asymmetry it is suggested that spontaneous variations giving advantageous dextrality would arise and persist as soon as these functions were liberated from the influence of bilateral motions. It is likely, therefore, that right-handedness in the child is due to differences in the two half-brains, reached at an early stage in life, that the promise of it is inherited, and that the influences of infancy have little effect upon it, the speech function being a further development of the same unilateral potency for movement found first in right or left-handedness.

Muscular Sense of the Blind.

Hocheisen in an article in the *Zeitschrift f. Psych. u. Phys. d. Sinnesorgane*, V, p. 239, applies Goldschneider's methods of research to the blind, making 9000 experiments to determine how great an angular motion of a joint is required to be perceived as motion. He found a small but demonstrable increase in the fineness of the discrimination which is greater in the young. Localization is said to be but little more acute in the blind and the increased muscular discrimination is referred to development of attention. It is, in other words, due to purely psychical causes. Small motor acts play a large part in the reading of the blind.

Special Nerves for Pain ?[1]

The author's position is indicated by an early sentence of the paper : "I shall endeavor to show; first, that the weight of psychological evidence is strongly negative to a classification of pain with sensation; and second, that the arguments brought forward in support of such classification, and of the existence of brain localization and of nerve tracts and terminals for pain, are not concial."

He objects to the association of pain with sensation 1st, because the former is not directly determined by special relation to the environment.

2d. Because of the relation of pain to pleasure, both being emotional rather than sensational, there should be "pleasure nerves" also.

3d. The same difficulty exists in the location of cortical centres; and supposed "pain centres" are probably sensation centres of cutting and pricking.

4th. The fact that intellectual states are pleasurable and painful the author thinks differentiates pleasure and pain from sensations. [This, however, rests on a fallacy. Intellectual states give rise to pleasure or pain which is just as real as a sensationally produced pleasure or pain and has its physiological basis also.]

5th. Pleasure and pain differ from sensation in the ease with which one passes into the other.

6th. In the case of pleasure-pain the states do not vary concomitantly with the intensity of the stimulus.

7th. The relation between stimulus and result is inconstant.

The objection at once suggested that mechanical and other stimulation of nerves produces pain but not pleasure is met by the suggestion that these methods are too crude to awaken pleasure and especially by the fact that pleasure is largely due to summation of stimuli. The question of *sequence* of temperature and tactile sensations on one hand and pain on the other may be dismissed. The facts of analgesia which have been held to tell in favor of the existence of special pain nerves may be interpreted to mean that the capacity to experience one form of sensation of a certain part of the body is cut off and with it its painful elements. The observations of Schiff supposed to require special paths in the cord are interpreted in the same way. Goldschneider's observations are not sustained by those of

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[1]MARSHALL, H. R. *Journ. Nerv. and Mental Disease*, XIX, 2.

later observers, who find termini for heat, cold and pressure but none for pain.

The author concludes that the determinants for pleasure and pain are matters of intensity not of kind and that no paths or loci in the central organs are to be sought.

The reviewer may add that even though pain or pleasure is due to special intensities this does not prevent us from accepting the possibility that a certain degree of excitation may be possible only in case the stimulus has overflowed from the direct tracts and passes through a succession of short circuits in the gray matter of the cord. There is much to suggest that pleasure and pain are associated with summations and irradiations of stimuli, and this fact is also responsible for the close relation which these affections have to the vaso-nervous mechanism.

Mirror-writing.

An illustration of this curious peculiarity is given by Dr. C. K. Mills in the Journal of Nervous and Mental Disease for Feb. 1894. A boy of thirteen with right-sided partial paralysis and atrophy writes with the left hand in mirror reverse. The author remarks: "The right side of the brain is not functionless, but its functions are in part, and sometimes largely, in abeyance. When the individual has the perfect use of the left half of his brain—is right handed, has the usual expertness with his right hand, has speech and vision in accordance with his inheritance and his training—impressions which come to him through his eyes are received and transmitted both by the lower and higher visual centres, so as to present to his consciousness a normal or usual image, which, as a rule, has been registred only by a visual centre of the left hemisphere. In this centre the images are usually recognized as right side up; the image formed on the right side, if one exists, is probably usually suppressed. When now the left side of the brain is destroyed, or when, as in the case of our patient, its development has been arrested, the individual is guided in writing by images formed on the right side of the brain.

Nerve-Endings in the Teeth.[1]

The author has applied the Golgi method to fishes and lizards. In fishes the nerve fibres course on the surface of the pulp only; while in lizards, as in mammals, there is an axis with dendritic branches.

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[1]ROESE, C. Ueber die Nervenendigungen in den Zähnen. *Deutsch. Monatsschr. f. Zahnheilk.* XI, 2.

"The finest fibrils penetrate between the odontoblasts and end for the most part directly under the shank of the tooth with free tips, which are here and there nodose. A penetration of nerve-fibres into the shank of the tooth was nowhere observed."

An Examination of Weismannism.[1]

The publication from an American house of this volume of essays is another indication of the widespread interest which Dr. Weismann's speculations have excited. Like the original essays, which it criticises, this book is a growth, the chapters having been in several cases called out by radical changes in Dr. Weismann's own views. The founder of Weismannism has of late successively receded from so many of the positions which were formerly considered characteristic of that school that one wonders if it would not be better if he were to recede from the few that remain.

Dr. Romanes says, "Upon the whole, then, it appears to me that both the fundamental postulates of the theory of germ-plasm are unsound. That the substance of heredity is largely continuous and highly stable I see many and cogent reasons for believing. But that this substance has been uninterruptedly continuous since the origin of life, and absolutely stable since the origin of sexual propagation, I see even more and better reasons for disbelieving. And inasmuch as these two latter, or distinctive, postulates are not needed for Weismann's theory of heredity, while they are both essential to his theory of evolution, I cannot but regret that he should thus have crippled the former by burdening it with the latter. Hence my object throughout has been to display, as sharply as possible, the contrast that is presented between the brass and the clay in the colossal figure which Weismann has constructed. Hence, also, my emphatic dissent from his theory of evolution does not prevent me from sincerely appreciating the great value which attaches to his theory of heredity."

In concluding Chapter V, "Weismannism up to date (1893)," the author states, "By surrendering his doctrine of the *absolute* stability of germ-plasm on the one hand, and of its *perpetual* continuity on the other, Weismann has greatly improved his theory of heredity. . . .

In my opinion it only remains for him to withdraw the last remnant of his theory of evolution by cancelling his modified and even less tenable views on amphimixis, in order to give us a theory of

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[1]ROMANES, G. J. An Examination of Weismannism. Open Court Publishing Co. Chicago, 1893.

heredity which is at once logically intact and biologically probable. The theory of germ-plasm would then resemble that of stirp in all points of fundamental importance, save that while the latter leaves the question open as to whether acquired characters are ever inherited in any degree, the former would dogmatically close it." These quotations perhaps will serve to give the author's point of view.

The publishers have given us a neat and handy volume which is in every way worthy of its subject-matter. C. J. H.

Practical Biology.[1]

We deem it a pleasure to call the attention of educators to Professor Dodge's manual. The book is intended for a laboratory guide, and instead of instructions for dissection or descriptions to be verified, the matter has been cast in the form of questions which can be answered only from the specimens. The types are so chosen and the questions are so framed that the student should come out of the course supplied not only with some zoological and botanical facts but with a good introduction to Biology in the true sense of the term. From this point of view the physiological studies upon each type are perhaps of the greatest value, as they are far-reaching and yet not too difficult for the tyro. In spite of the prevailing tendency, under the influence perhaps of Professor Huxley's example, in American colleges, the author adheres to the logical and biological sequence, proceeding from the simple to the more complicated. Many of our best teachers will find the book more acceptable for this reason.

C. J. H.

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[1]CHARLES WRIGHT DODGE. Introduction to Elementary Practical Biology. A Laboratory Guide for High School and College Students. *New York, Harper and Brothers*, 1894.

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9. STEIN. Zur Behandlung der Epilepsie.

Most of the above are briefly reported in *Deutsch. med. Wochenschrift*, 42. Oct., 1893.

LITERARY NOTICES.

Pleasure and Pain.[1]

This paper is essentially a discussion of the recent work by Marshall on the same subject.[2]

It is therefore an attack on the so-called *quale* theory of pleasure and pain—a theory which considers pain not a sensation but a form of feeling and maintains "that all states of pleasure and pain are included in a single series or continuum, passing from intense pleasure through agreeableness, to extreme pain, and that all the several varieties of pleasure and of pain are but phases or aspects of one and the same mental element," in fact "pleasure-pain is an attribute whose various phases must be considered as primary quales which affect all presentation however wide, however narrow, somewhat after the manner in which we grasp the notion of intensity as being common to all presentation." Pleasure-pain is the Gefühlston of the German.

The author says "When, therefore, Mr. Marshall insists that a pleasure or a pain is not to be classed as emotion, nor as intellect, nor as will, although pleasure-pain phases accompany all these states, he is saying, in effect, that these states are complexes, and that pleasure or pain is one of the component elements, an entirely unobjectionable statement of fact. But when, under the requirements of the quale-doctrine, pleasure and pain are classed together as similar phenomena, some violence would seem to be done the facts of introspection."

The author does not consider it improbable that we may soon hear of the discovery of a specialized sensory nerve of pleasure, with a localized cerebral centre.

He states that:

1. Pain is presented in consciousness with the distinctness, the definiteness, the vividness, and the isolation that are supposed to characterize all sensations.

2. Pleasure is a mental phenomenon as distinct from pain as heat is from cold, or a sound from a color.

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[1]WITMER, L. The Psychological Analysis and Basis of Pleasure and Pain. *Journ. Nerv. and Mental Disease.* XIX, 4.

[2]MARSHALL, H. R. Pain, Pleasure and Æsthetics. Macmillan & Co.

3. It may with reservations be maintained that agreeableness and disagreeableness accompany every mental state; but these are given in consciousness not as phases of a dependent quale or attribute, but as simultaneously presented elements.

Reference is made to Münsterberg's theory that reflexly produced flexions and extensions are the conditions of those conscious processes which we call agreeableness and disagreeableness, and this is placed in connection with Osswald's discovery that from the same motor nerve root electrical, chemical, mechanical and thermal stimuli may, according to the intensity and duration of the stimulation, produce movements of either flexion or extension.

Marshall's theory that "the activity of the organ of any content, if efficient, is pleasurable, if inefficient, painful" is summarily dismissed, apparently because, as the author confesses, it is not understood. Throughout the whole paper there is a very remarkable ignoring of the element of irradiation which is the key to the physiological aspect of this problem. It would seem that evidence is now sufficient to show that the method of translation of the pleasure-pain stimuli is one of the most important physiological differentials. Absolute reliance is placed on Goldschneider's localization of hot, cold, and pain spots on the skin, which has not been supported by recent careful experiment. The present reviewer is far from convinced that the author proves that the existence of pain centres, tracts and peripheral nerves can be brought into accord with the results of introspective psychological analysis and still less convinced that recent discoveries in neurology offer evidence for the existence of such organs. It is far more probable that stimuli of certain intensities have the faculty of irradiation or overflow and are thus conveyed (often slowly) through accessory channels or pass from cell to cell until summation phenomena are developed which have genetic relation with sensation but differ in their "massiveness." In some cases the irradiation is facilitated by the state of the paths, in others it is inhibited. Repression may produce local accumulation and destructive violence, while facile translation produces acceleration of function; thus a physical basis for pleasure-pain is afforded. On the other hand the state of the transmitting organs may be modified by central states so that the same peripheral stimulus may at one time prove pleasurable, at another painful. The corresponding feelings are analogously related. It is believed that a physiological basis for the resistance theory is much more easy to find than for a theory of specific centres.

C. L. HERRICK.

Bowne's Ethics.[1]

The two leading thoughts claimed by the author for this work are: first, the necessity of uniting the intuitive and experience schools of ethics in order to reach any working system; second, that the aim of conduct is not abstract virtue but fulness and richness of life.

The author defines his point of view clearly enough in denying the relevancy of a study of the psychological faculties concerned in the production of moral ideas, the nature of conscience, etc., to ethics proper, which must confine itself to the study of our moral ideas themselves with their postulates and the application of the theory thus reached to concrete conduct. In fact he states explicitly that,

1. The pretended deduction of moral ideas from non-moral is purely verbal and fictitious.

2. The pretended reduction of moral ideas to non-moral elements is likewise purely verbal and fictitious.

3. The actual order of graded development in the mental life cannot be understood as a modification of its earliest phases, but only as the successive manifestations of a law immanent in the whole development.

4. No psychological theory concerning the origin and genesis of our ideas, moral or otherwise, can be used as a test of truth, or as a method of discovery, at least so long as the general trustworthiness of reason is allowed.

After warning against the confusion of the doctrine of goods [the good] with a coarse utilitarian conception which looks only to external and marketable values the author reaffirms Schleiermacher's position that good, duty, and virtue are the fundamental moral ideas and that their order is that just given. Duty ethics and the goods ethics are reconciled as follows: "Our constitution makes various goods possible. These are the various forms of well-being founded in the essential structure of our minds and in their external relations. As such they are natural and not moral. They are not expressions of character, but only of nature. But while themselves only natural, they furnish the condition of all moral activity." "The moral is the natural glorified and realized by rational freedom." As applied to conduct, he concludes, consequences are the criteria of material rightness; but to the agent belongs the duty and merit of its realization.

We cannot extend this summary to the body of the work, but

[1] BOWNE, B. P. The Principles of Ethics. *Harper and Brothers.*

must content ourselves with a glance at a few of the conclusions reached:

1. The spiritual is the natural itself rising toward its ideal form through the free activity of the moral person.

2. The field of ethics is life itself and its task to make this life, as far as possible, an expression of rational good will.

3. A conditional life like ours cannot reach its ideal form, unless it be in harmony both with its objective environment and with its subjective ideals.

4. The moral life finds its chief field in the service of the common good. Neither virtue nor happiness is attainable as a direct abstract aim.

5. The greatest need in ethics is the impartial and unselfish will to do right. In fulfilling this need abstractions should be neglected and ethical considerations should be applied thoughtfully to the problems of life and conduct.

6. Righteousness is not to be achieved once for all—it is a living will to do right, ever adjusting to new conditions.

7. The respectable class is the dangerous class in society. By its indifference to public good it becomes the accomplice of all the enemies of society. [We can hardly agree with the author that the "ease with which self-styled good people ignore public duties and become criminal accomplices in the worst crimes against humanity *is one of the humorous features of our ethical life.*" It is one of the saddest prophecies of social dissolution for which the apathetic church of our generation is chiefly responsible. A temporizing and effeminate clergy, fearful of antagonizing subsidized interests, fosters the inclinations of its constituency and, disclaiming any connection between the church and public morals, has led to the easy conclusion that there is no connection between religion and public morals.]

The chapter on the development of morals is characteristic. Admitting that first in the development of man we find a body of instincts, appetites and passions which lie back of all volition, he disallows the importance of evolution for morals. He says: "Innumerable deductions of moral faculty have been vouchsafed us, in which flogged curs have played a notable part. Luckily, this philosophy and its four-footed accomplices have had their day." This fling at comparative psychology is gratuitous and likely to react strongly against the author's position, especially as he admits that the animal elements in the psyche furnish the raw material of life. The attempt to isolate ethics is incongruous with the author's views of conduct.

The book is clearly and even elegantly written, and, while the reviewer deprecates the isolated point of view, he sympathizes with the results reached and feels sure that the perusal of the volume will reward every reader.

A Primer of Psychology and Mental Disease.[1]

Of this little book, which seems to be a syllabus of lectures delivered before training school classes, a favorable opinion may be expressed. Parts II and III relating to insanity and the management of cases of insanity are condensed compendia which put in convenient form the most important facts. The definitions are clear and the few suggestions as to treatment are intelligently selected.

Part I, Psychology, is less satisfactory, though comparatively few modifications would suffice to adapt it to the immediate requirements of the book. To illustrate the nature of the imperfections a few examples may serve. On page 2 we are told that "the lowest form of life is that of the amœba." On page 6 a "muscular sense" is recognized as coördinate with the special senses. On page 7 sensation is excluded by definition from a place among the psychical elements (which after all is perhaps more consistent than the prevailing view.) On page 8 we are taught that the child perceives that the object is the cause of sensation. This seems to the reviewer a serious lapse. The illustrations also seem at times to convey a loose or quite erroneous idea, as where each grape is said to represent the memory of a percept and these united by the stem ideation form the concept. In spite of such imperfections the booklet cannot fail to be of service in the work for which it is intended.

The Psychology of Attention and The Diseases of the Will.

Professor Ribot's well-known volumes have been brought out in new authorized translations by the Open Court Publishing Co., Chicago. The books are printed with the same care and neatness which has characterized the previous publications of this house.

The Sense of Direction in Pigeons.[2]

Dr. Hodge has contributed a considerable mass of exact observation to the solution of the vexed question as to the so-called "sense

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[1] Burr, C. B. Medical Supt. Eastern Michigan Asylum. *George S. Davis, Detroit.* 1894.

[2] Hodge, C. F. The Method of Homing Pigeons. *Pop. Science Monthly* XLIV, 6.

of direction" of lower animals. Pigeons which had been long confined in a loft from which they had but a limited view of the immediate neighborhood were taken to an eminence, in some cases in an open basket and in others blindfold. The course pursued is mapped in each case. The same birds were subjected repeatedly to this treatment in order to discover the effect of practice.

It proves that the blindfolded pigeon may fly fifty miles in finding its home, a good sized barn half a mile away. A week later he flies home in less than a minute. The course pursued shows that the flight is largely directed by prominent objects more or less resembling that sought—in this case other red barns, etc. Considerable difference in discriminating power was observed and Dr. Hodge concludes that there are stupid pigeons as well as stupid men.

The experiments are supplemented by tracings of the course persued by various individuals in search of small objects concealed in a small area, and many of these paths are found to agree with the theoretically most economical course quite closely.

The conclusion deducible from these studies obviously is that lower animals determine their course by psychical processes whose various steps express themselves much in the same way that human intelligence would under similar conditions.

The Homing of Pigeons.[1]

A series of experiments extending over two years and still in progress contributes further evidence against the so-called "ortssinn." The experiments were designed to collect evidence as to the role of the semicircular canals in the homing of pigeons.

In the first study six pigeons were used, three placed in one basket, three in another, both baskets being covered. Both baskets were now carried 35 kilometers from Vienna, one as quietly as possible, the other suspended by a string and rotated at every change of direction. When liberated the occupants of the second basket flew back to the starting point in Vienna with as great precision and speed as the others.

In the second study four pigeons were used, all of which on the outward journey were hooded. Through the head of two of them at every change of direction an electrical current was passed sufficient to produce giddiness and thus to disturb the power of orientation.

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[1]EXNER, S. Negative Versuchsergebnisse über das Orientirungsvermögen der Brieftauben. *Sitz. Akad. Wiss. Wien.* CII, Heft 3-7, 1893.

One control pigeon and one galvanized pigeon never returned. Of the others, the galvanized pigeon returned more than 40 hours sooner than the control. The two latter were old, the former, young. A third and a fourth study with essentially the same conditions gave similar results. The author therefore concludes that sensations received by the vestibular apparatus play no part in the homing of the birds.

To answer the question whether any experiences of any sort gained in the outward journey served to direct the return flight several specimens were put under the influence of ether and carried to a distance. They returned as well as the control specimens.

The Cause of Fatigue.[1]

It is shown that the preliminary stages of fatigue are due to the toxic effect of a substance operating in situ. A sort of "auto-curarization" results in a paralysis of the end-organs of the nerve. After a time the muscle itself loses its excitability. By cutting off the circulation in one leg and tetanizing the frog by placing one electrode in the mouth and the other in the cloaca, this member was less wearied than the other in which the circulation was not disturbed, thus showing that the substance is produced throughout the whole body, the ligatured leg being affected only by that produced within it.

Craniotomy in Microcephalus.[2]

In one of the two cases reported, a child five years old, epileptic and idiotic, was operated upon on both sides with remarkable improvement. The child has grown physically and the face has become intelligent, while anything ordinarily understood by children of the same age is readily comprehended.

Syphilis of the Nervous System.[3]

This subject has been discussed by Dr. F. Raymond in a series of articles which are based upon extensive histological studies. At the

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[1]ABELOUS, J. E. Contribution à l'Etude de la Fatigue. *Arch. de Phys.* 1893, 3.

[2]PARKHILL. Linear Craniotomy in Microcephalus, with a Report of two Cases. *Intern. Med. Mag.* Nov. 1893.

[3]Contributions à l'étude de la syphilis du systeme nerveux. Paralysie générale, méningo-myélite vasculaire diffuse et lèsions syphilitiques des vaisseaux. *Archives de Neurologie*, XXVII, 84, Feb., 1894.

close of the discussion of the third case the following conclusions are presented:

In general paralysis of syphilitic origin the vessels of the cerebral cortex are first affected. This alteration may be limited to the minute vessels of the cortex and pia, but it may also descend far down to the vascular trunks until the larger arteries and veins of the brain are affected. General paralysis, at least that which is syphilitic, is then a diffuse vascular encephalitis. But every case of diffuse vascular encephalitis is not general paralysis. The latter occurs only when the nervous elements begin to suffer from the bad condition of their nutritive apparatus. They may resist for a very long time. During this phase there may be observed only vague and variable symptoms, such as neurasthenia, hypochondria, etc., which will vary with the predispositions of the patient. At a give moment the nervous tissues yield and the purely vascular encephalitis becomes mixed. The neuroglia elements become hypertrophied and sclerous; the nerve-tubes disintegrate first at the superficies of the convolutions, the cells are altered and the lesion of the cortex becomes incurable. Hereditary factors no doubt have a large part to play in determining how long the nervous elements can resist before they succumb to the disease.

The Occipital Cortex in Anophthalmia.[1]

The author finds that in cases of Anophthalmia and atrophy of the optic bulb, (1) some layers in the cortex of the sulci calcarini are absent altogether; (2) those remaining are more or less reduced; (3) the missing layer is the fourth (clear banded layer with scattered neuroblasts); (4) the fifth layer (normally granular, consisting of numerous crowded small cells, mixed in part with larger neuroblasts) is reduced, the larger cells being absent, the smaller atrophied, but not diminished in number.

Pathologic Lesions in Insanity.[2]

The pathological anatomy of insanity in its simple, acute and the so-called partial forms, is yet largely a matter of conjecture. In a

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[1]LEONOWA, O. v. Ueber das Verhalten der Neuroblasten des Occipitallappens bei Anophthalmie und Bulbusatrophie, und seine Beziehungen zum Sehact. *Archiv f. Anat. u. Phys.* Anat. Ab., 5-6, 1893.

[2]Editorial in the *Journal of the American Medical Association.* XXII, 10, March 19, 1894.

very large proportion of the cases of acute insanity we are forced to fall back on the assumption of microscopic changes as yet beyond the scope of our powers of observation, or to assume, as might perhaps be done in accordance with the later pathologic theories, a toxic action directly on the brain. To those who wish to hold to the theory of microscopic changes in the brain, the comparatively recent researches in the minute anatomy of the nervous system by Cajal, Kölliker, Van Gehuchten and others may afford some suggestions. Gowers, and more recently Ferrier, have emitted the supposition that derangements of the terminal end-brushes of the spinal nerves may account for certain spinal diseases, Landry's paralysis, for example, the pathology of which has thus far eluded our search; and Tanzi in a review of the recent progress of research in the anatomy of the nervous system has suggested that the perfection or otherwise of contact, or rather contiguity, of these processes to the nerve cells will account for the facts of consciousness and mental capacity. According to his theory he accounts for certain actions, once conscious and labored, becoming unconscious and automatic by the supposition that the contiguity of the nerve fibrils to the cells has reached its maximum and thus affords the least possible interruption or hindrance to the nerve wave, and by the same method of reasoning he explains the various degrees of individual capacity for different kinds of work. It is not difficult to see how this line of argument could be applied to psychic derangements. It suggests an interesting, though rather difficult line of microscopic research which may or may not be fruitful of results.

The Evolution of the Preoral Lobe.[1]

The author, who has elsewhere attempted to show that the ascidian larva is morphologically a preoral lobe homologous with the head cavities and preoral coelom (+preoral pit) of Amphioxus and the proboscis of Balanoglossus, considers that many indications point irresistibly to the conclusion that the prime factor which must be recognized in the evolution of the preoral lobe, from the relations which it sustains in invertebrates to those which it holds in the Protochordata and vertebrates is its complete emancipation from the central nervous system.

In annelids, molluscs and arthropods the preoral lobe is the seat of the cerebral ganglion. This lobe (or apical plate) in the Trochophore larvæ of annelids and molluscs is the main if not the sole ele-

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[1]Willey, A. *Anat. Anzeiger.* IX, 11.

ment of the central nervous system, but in Balanoglossus the central system is solely represented by the apical plate of the preoral lobe. This plate disappears during the development and is substituted for by the medullary tube. In the ascidian and Amphioxus the apical nervous system does not develop in any stage. Thus the vertebrate lacks the preoral nervous system because of its transformation in lower types into an organ of fixation or locomotion.

The Cortical Physiology of Mastication and Deglutition.[1]

In the dog and the rabbit the common centre of mastication and deglutition lies on the cephalo-lateral border of the centre for the extremities. Electrical stimulation of this region produces not merely contraction of the masseter and its associated muscles, but the coordinated movements of the lips and tongue. If the animal is not too deeply narcotized a complete act of swallowing follows from the same stimulus.

The accompanying diagram illustrates one set from a number of typical curves as recorded on a kymograph: No. 1 indicates the duration of the stimulus, No. 2 marks seconds, No. 3, the movements of the lower jaw, No. 4, the movements of the larynx.

Fig.3. Cortical centre of mastication and deglutition in the rabbit.

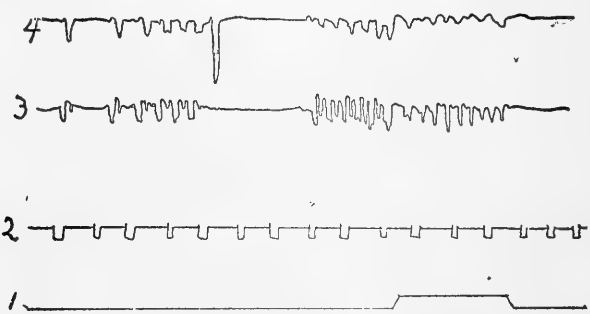

Fig. 4.

Further localization experiments on the cut surface of the brain after the removal of successive transections from before backwards reveal the course of the subcortical tracts. They pass ventrad through

[1] RETHI, L. Das Rindenfeld, die subcorticalen Bahnen und das Coordinationscentrum des Kauens und Schluckens. *Sitzber. kais. Akad. der Wiss. Wien.* CII, 3–7, 1893.

two thirds of the thickness of the hemisphere, then to the regio-subthalmica in the peduncular region. Irritation anywhere along this tract produces the entire sequence of motions shown in the curves. From this point caudad, however, coordination ceases and contraction of the masseter only follows stimulation. This, then, is looked upon as the coordination-centre for these muscles.

Tentacles and the Morphogenesis of the Head.[1]

An exhaustive study of the tentacles and their nerves convinces the author that the tentacles of Myxine are the homologues of the oral cirri of Amphioxus and the comparison further shows that the ancestors of Myxine must have possessed at least eight pairs of oral cirri. The branches of the ophthalmicus, the maxillaris, coronoideus, mentalis and sub-mandibularis are nerves corresponding to several segmentally arranged nerves of Amphioxus. Greater difficulties are encountered in ascertaining the homologies of tentacles which occasionally appear in Gnathostomata but it is thought that the siluroid fishes present hitherto unrecognized homologies with Myxine in the nervous and skeletal elements. They are of the same type and can be traced back to an Amphioxus-like ancestor.

Gegenbaur homologized the labial structures with gill bars but the author regards them as the remnants of a set of organs—the oral cirri. The suggestions are reenforced by hints from Paleozoic fishes. Evidently comparisons with amphibia are here in order.

Functions and Functional Development of the Semicircular Canals.[2]

The author has experimented quite extensively upon invertebrates, subjecting them to rotation in various ways, and concluded that invertebrates do not exhibit those forced motions which are so characteristic of vertebrates after rotation. There is, in fact, a sharp contrast in this respect between vertebrates and invertebrates and this is attributed to the absence of the labyrinth in invertebrates. It occurred to the author that young vertebrates, in which the labyrinth is as yet undeveloped, might afford additional evidence. The tadpole is a suitable subject for such experiments as the first evidence of a semicircular canal appears on the 10-11th day and it is not until the

[1] Pollard, H. B. The "Cirrhostomial" Origin of the Head in Vertebrates. *Anat. Anzeiger.* IX, 11.

[2] Schaefer, Karl L. *Zeitschr. f. Psychologie u. Phys. d. Sinnesorgane.* VII, 1.

15th that the canals are approximately distinct. Experiments showed that up to the 14th day there was no suggestion of rotary or forced motions after the passive rotation, while on the 15th it was obvious and increased for some time thereafter. The coincidence between the time when the canals become anatomically differentiated and that at which the effects of dizziness first appear is construed as evidence in favor of the theory that the labyrinth has a static function.

Neuro-Muscular Changes in General Paralysis.[1]

The history of twelve cases of general paralysis of the insane with autopsies and full histological examination. The following points are taken from the author's synopsis :

Changes in the Vagi. In all cases extensively and strikingly diseased, more so almost than any of the peripheral nerves, and decidedly more so than any cranial nerve. Too much importance cannot be attached to the remarkable singling out of the vagi for such extreme degeneration in this disease. A similar affection obtains in alcoholic polyneuritis, a disease distinctly produced by a toxic infection, also in other diseases (diphtheria, etc.), and in all it is unquestionably accountable for serious clinical changes. In general paralysis it explains the cardiac troubles so often met with. Anatomically, most pronounced degenerative changes were demonstrated in the muscular elements of the heart in cases in which the vagi were diseased. Phrenic nerves were always diseased, but less so than the vagus trunks.

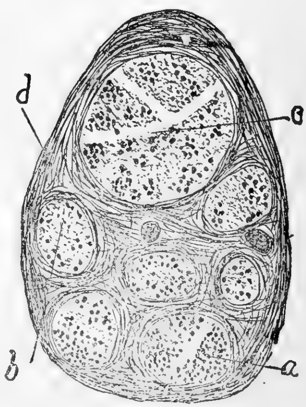

Fig. 1. Transverse section of Vagus. Weigert's method. a, healthy nerve fibres; b, unstained fibro-cellular tissue (remains of diseased fibres;) c, extremely diseased large bundle containing few healthy fibres: d, thickened perineureum.

Changes in the mixed spinal nerves and their peripheral terminations. The alteration appears to be a combination of a parenchymatous degeneration and an interstitial or adventitial inflammation. The exist-

[1]CAMPBELL, ALFRED W. A Contribution to the Morbid Anatomy and Pathology of the Neuro-Muscular Changes in General Paralysis of the Insane. *Jour. Men. Sci.*, XL, 169, April, 1894.

ence in that portion of the nerve trunk from which healthy nerve fibres have disappeared of a number of very small nerve tubes with extremely thin medullated sheaths, unstained by Weigert's hæmatoxylin or the modifications of Weigert's methods is very remarkable. The change appears to be a textural reversion to an embryonic or lower type, comparable with the pial adhesions, the subpial felt-work, and the enormous nuclear proliferation occurring in the cortex cerebri. The more peripheral the site examined in the mixed trunk, the more extensive will the degeneration be found to be.

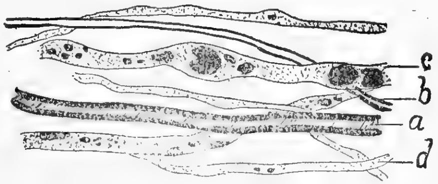

Fig. 2. Intra-muscular nerve, bundle-teased. Osmic acid. a, healthy nerve fibre; b, small nerve fibre; c, nerve fibre undergoing acute parenchymatous degeneration; d, advanced degeneration.

Spinal nerve roots. Degeneration always considerable, but never extensive. In the posterior root ganglia no obvious degeneration of nerve cells beyond some hyperpigmentation was noticed, and the posterior roots beyond the ganglia were but little diseased.

Changes in the muscles. In brief the changes noted are fatty degeneration, atrophy, and complete or partial disappearance of a number of muscle fibres, with proliferation and increase of the nuclei of the sarcolemma and connective tissue. The number of motor endplates is reduced.

Cranial nerves and their nuclei of origin. The existence of more or less constant interstitial degenerative changes in many of these nerves is confirmed. The changes are most marked at the periphery. The ascending root of the fifth in the medulla in many cases markedly sclerosed. The vagus nucleus most strongly affected, in many others traces of degeneration.

The author classifies general paralysis as a primary intrinsic toxœmic multiple neuritis. The changes occurring in general paralysis are certainly compatible with those seen in those toxœmic neurites in which the virus, so far as is known, is primarily and intrinsically produced within the body independently of any definite or known disease, and, further, such a morbid blood state provides us with a far more reaching and sufficient explanation of the general widespread disposition of the disease and many of its other characteristics. The peripheral neuro-muscular alterations are not looked upon as of secondary origin. The fact that the more peripherally situated portions of nerves are most diseased is explained in this condition, as in some other neurites, by their situation; there they are furthest removed from their trophic supply and being the most highly organized and functionally susceptible parts of the nerve they are placed at a disadvantage. A toxic agent would in this situation operate with greatest effect. We assume this applies to motor and sensory nerves alike.

Destruction of the Ganglion Coeliacum.[1]

The functions and mutual relations of the visceral sympathic ganglia have long been questions upon which the greatest diversity of opinion prevails. It is natural to associate them with the viscera with which they are topographically associated, but the full review of the literature which accompanies the paper before us shows that the existing data are meagre and the interpretations most contradictory.

That these ganglia are sensitive has been experimentally proven and Bichat, Jolly and others claim that they are subject to special neuralgias or colics. Gee has ascribed to the ganglion a "coeliac affection" characterized by a chylous diarrhœa in young children.

Experimental results are conflicting. Munk and Klebs found, after extirpation of the coeliac ganglion, diabetes insipidus and atrophy of the pancreas; Peiper, however, considered the diabetes incidental to the operation and noticed no atrophy of the pancreas. More recently the attempt has been made to connect injury of the coeliac ganglion with the peculiar affection known as Addison's disease.

The authors made elaborate experiments in this direction, either extirpating or crushing the ganglion. We cannot reproduce the tabulated results which are carefully recorded in the original. The author's conclusions are as follows:

1. The coeliac ganglion is among the most susceptible to pain of all nervous organs.

2. After partial extirpation a part of the ganglion may substitute vicariously for the whole by enlargement.

3. The extirpation or crushing of the ganglion does not necessarily produce a rapidly fatal result.

4. The principal effect of such injury is paresis of the intestine with diarrhœa and meteorismus. Experiment also shows that the motor centres for the peristaltic motion of the intestine are in this ganglion.

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[1]LEWIN and BOER. Quetschung und Ausrottung des Ganglion coeliacum. *Deutsch. med. Wochenschrift*, 10, 1894.

No changes were observed in Auerbach's or Meissner's plexi in the intestine itself. Comparing with the symptoms of Addison's disease it appears that the characteristic visceral pains of that disease might be due to disease of the ganglia coeliaca, the same is true of the digestive disturbances, but the color changes characteristic of the disease are not reproduced by injury to the ganglion. The anorexia of Addison's disease is not produced by injury. The aceturia sometimes observed is incidental.

The Nerves of the Heart of the Crayfish.[1]

In a communication largely occupied with citation of literature and dealing with the vertebrate heart the author describes the ganglia of the crustacean heart.

He finds a continuous chain of ganglion cells the full length of the heart, which fall chiefly into two groups, an anterior and posterior. In addition there are other scattered cells. The cells vary in size and form, being unipolar and multipolar, with branching processes extending among the muscles.

The nerve fibres anastomose much as in the nerves of the mammalian heart. The muscles of the heart are said to be devoid of nuclei.

The presence of these cells explains the long continued activity of the heart after removal. The histological results were obtained with gold chlorid. The parts of the opened heart were expanded and treated with 20 % formic acid for 3 to 5 minutes, then, after washing in water, with 2 % gold chlorid for 5 to 20 minutes and left in 20 % formic acid 12 hours. Two excellent plates accompany the paper. The comparisons with the vertebrate heart seem a little forced.

Orbital Nervous System of the Rabbit.[2]

Detailed anatomical descriptions, tables and illustrations of the nervous connections within the orbital cavity. The ciliary ganglion was extirpated with the following results: Expansion of the pupil, paralysis of accomodation and pupil-reflexes, and considerable dimunition of the tension of the eye-ball at first. The unoperated eye either remained normal or exhibited myosis, hyperæmia of the iris, and peri-corneal injection.

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[1]DOGIEL, J. Beitrag zur vergleichenden Anatomie und Physiologie des Herzens. *Arch. f. mik. Anatomie*, XLIII, 2.

[2]PESCHEL, M. Ueber das Orbitalnervensystem des Kaninchens mit specieller Berücksichtigung der Ciliarnerven. *Arch. f. Ophth.* XXXIX, 2.

Cranial Nerves of the Anura.

Mr. G. A. Arnold[1] has given in a brief paper another illustration of the excellent results secured by the study of reconstructions of

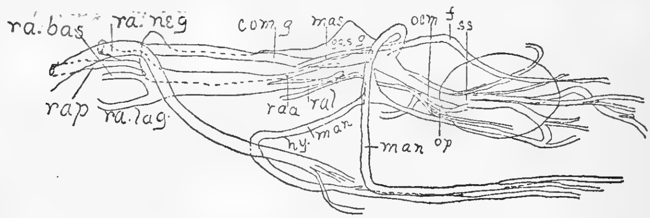

Fig. 5. Nervous system of Pipa from the right side.

cranial nerves from serial sections. He has done for the Anura what Von Plessin and Rabinowicz have already done in the case of Salamandra. The present study is based upon reconstructions of transverse serial sections of embryos 9 mm. in length. We reproduce sketches from the authores figures which will render unnecessary any extended discussion of the relations.

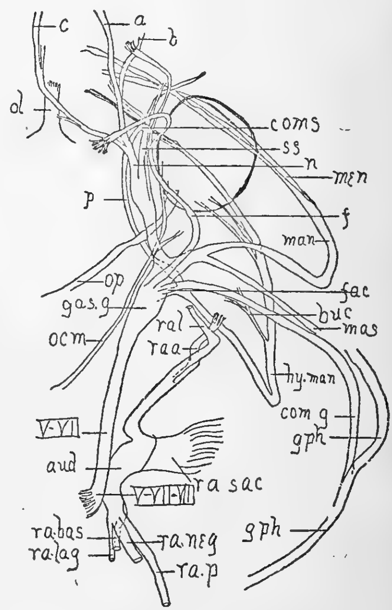

Fig. 6. Nervous system of Pipa from above.

Explanation of reference letters: *a*, *b*, *c*, terminal branches of nasalis; *buc*, buccalis; *com. g*, commissure of VII and IX; *coms*, commissure between palatinus and maxillaris; *f*, frontalis; *fac*, facialis; *gph*, glossopharyngeal; *gas. g*, ganglion of V and VII; *hy. man*, hyomandibularis; *man*, mandibularis; *men*, mentalis; *mas*, masseter; *n*, nasalis; *ocm*, oculo-motor; *ol*, olfactory; *op*, optic; *r.a.a*, ramulus acusticus anterior; *r.a.l*, ramulus acusticus exterior; *r.a.p*, ramulus acusticus posterior; *r. a. bas*, ramulus acusticus basilaris; *r. a. neg*, ramulus acusticus neglectus; *r. a. sac*, ramulus acusticus sacculi; *ss*, supramaxillaris superior; *troch*, trochlearis; V, VII, VIII, origin of these nerves from the brain.

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[1]The Anterior Cranial nerves of Pipa Americana. *Bulletin of the Essex Institute*, Vol. XXV, Nos. 10, 11, 12, 1893.

Nerve Endings in the Sexual Organs.[1]

A comparison of the results of the application of the Golgi and methyl blue methods to the details of the nervous organs in the testicles proves that the results of the former require to be extended and interpreted by the latter method.

By means of the Golgi method numerous nerve-fibres can be demonstrated following the course of the vessels about which they spread in the form of a plexus. Other fibres pass among the tubules, but none could be traced through the membrana propria as described by Sclavunos, who also described knob-like free termini between the semen-cells. These appearances the author attributes to imperfect impregnation and varicosities. In the epididymis fine fibres are found about the canals, but they may belong to the involuntary muscles. Methyl blue impregnation reveals a double plexus about the canals of the epididymis, the inner being fine-meshed and fine-fibred. The nerve fibres entering the epididymis are provided with ganglion cells which are enclosed in a fine pericellular plexus(sympathic ganglia.)

In the vas deferens other ganglia susceptible to stain are found. Intra-epithelial nerve fibres were nowhere found.

Histology of Secondary Degeneration.[2]

The material for this study was derived from a patient who had been injured by a bullet which penetrated the spinal cord at the level of the eleventh dorsal vertebra, completely destroying it at that point. The result was complete paraplegia lumbales with paranæsthesia and loss of muscle sense in both legs.

After death the cord was investigated by Marchi's and Weigert's methods. Caudad of the lesion the following changes were observed:

Both lateral pyramids were extensively degenerated. The remainder of the lateral columns and the ventral column exhibited a few scattered degenerate fibres. In the sacral region the degeneration seemed limited to the periphery of the ventro-lateral column. The dorsal columns show an almost uniform diffuse and compact degeneration leaving the so-called root zone and Flechsig's median zone along the dorsal septum relatively unaltered.

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[1]Timofeew, D. Zur Kenntniss der Nerven Endigungen in den männlichen Geschlechts Organen der Säuger. *Anat. Anzeiger*, IX, 11.

[2]Schaffer, Karl. Beitrag zur Histologie der secundären Degeneration. Zugleich ein Beitrag zur Rückenmarksanatomie. *Arch. f. mik. Anatomie.* XLIII, 2.

The extensive degeneration of the dorsal columns extends to the filum terminale. The collaterals extending through the dorsal cornua are uniformly degenerate. Passing cephalad of the lesion the following changes are noted:

The cerebellar bundle and Gower's column degenerate. Degeneration also occurs (diminishing as we leave the lesion) diffusely in the ventro-lateral column. The dorsal column is also degenerate, the column of Burdach being affected as far as to the nidulus of the funiculus cuneatus. This seems to prove that the external portion of Burdach's column contains tracts extending far down the cord thus contradicting the results of other observers. The author explains the discrepancy by assuming that the Weigert's method hitherto relied on for the demonstration of such degeneration is unreliable or at least not to be trusted in its negative results.

Weigert's method often fails to show secondary stages of degeneration which are very conspicuous by Marchi's method. Now since the different tracts do not degenerate cotemporaneously it is necessary to apply both methods to discover all degenerated bundles. The first to degenerate is Goll's column, then follows the pyramidal lateral column while the descending degeneration of the dorsal column and the ascending degeneration of Burdach's and Gower's columns and the cerebellar tract are later. The paper is accompanied by one plate.

Laminated Precipitates in Tissues Treated with Silver Nitrate.[1]

Dr. Hans Rabl finds evidence that the trans-striations described in nerves by Frommann and others is an artifact. He quotes extensively from other authors and presents a plate of his own preparations in substantiation of his view. He obtains a similar lamination in the adventitia of the blood-vessels, in the endothelial cells of the liver, in fat and cartilage.

Recent Views on Nervous Structure.

In the *Archiv fuer Anatomie und Physiologie*, 5th and 6th hefts for 1893, is a full translation of Ramon y Cajal's recent Spanish work.[2] In 110 pages are presented the essential results obtained by this author from application of the silver method to the nervous system.

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[1]Ueber geschichtete Niederschläge bei Behandlung der Gewebe mit Argentum nitricum. *Sitzungsb. der kais. Akademie der Wissenschaften. Wien.* CII Heft. 2-7, 1893.

[2]Nuevo concepto de la Histologia de los Centros nerviosos. *Barcelona*, 1893.

The various parts of the axial nervous system and the sense-organs are separately discussed with numerous diagrams and at the close a full bibliography is added. Many of the results we have already presented in abstract, but the original work is invaluable to those who wish to keep abreast of the recent progress in the cellular morphology of the nervous system. We can give now only the author's table of general conclusions.

1. There is an essential difference between the processes of nerve cells, epithelial cells and neuroglia cells. The nervous elements are true cellular units, or neurons, in the sense of Waldeyer.

2. There is no actual cellular continuity. The stimulus is carried from one cell to another by contact, as a current passes between two contiguous conductors. This contact is made between the terminal dendrid or collateral of the axis-cylinder on the one hand, and the cell body or its protoplasmic processes on the other hand. If the protoplasmic processes are absent, as in the spongioblasts of the retina, the unipolar cells of the spinal ganglia and the unipolar elements of invertebrates, then the surface of the cell-body serves as the point of application for the terminal dendrids.

3. The apparent path of a stimulus in a cell with both kinds of processes is such that the stimulus is cellulipetal in the protoplasmic processes and cellulifugal in the axis-cylinder. The latter only occurs in cells with only the one kind of processes (spongioblasts, etc.) The receiving apparatus (the cellulipetal, or better, karyopetal sphere) is the thin protoplasmic layer enveloping the nucleus.

4. In bipolar cells (acustic, olfactory, retinal, the sensory bipolar cells of worms according to Lenhossèk and Retzius, the bipolar sensory spinal ganglion cells of fishes, etc.) the peripheral process is strong and corresponds to the protoplasmic process, which is adapted for the reception of stimuli (cellulipetal activity.) In the unipolar cells of the spinal ganglia of Batrachia, Reptilia, Aves and Mammalia, the peripheral branch of the single process has the significance of a protoplasmic process, i. e., an organ for cellulipetal activity, while the central fine branch is a nerve fibre, an organ for cellulifugal activities. The single stem which contains both kinds of processes does not exist in the embryonic period (His); it is produced later by the withdrawal of the cell-body; it thus represents a part of the cell-body, not a nerve fibre.

5. The protoplasmic processes do not constitute, as Golgi and his school would have it, a nutritive apparatus, but like the axis-cylinders they have a conducting function. The only two supports found

by this author for his hypothesis, that the protoplasmic processes have a predilection to group themselves around the blood vessels and that they are connected with connective tissue cells, have not been verified either by Cajal himself nor by Kölliker, van Gehuchten, Lenhossèk, Retzius, Schäfer, etc.

6. The extraordinary length of some protoplasmic processes (pyramidal cells of the cerebrum, Purkinje's cells) and the abundance of their lateral and basal processes seems to be dependent upon the number of nervous terminal dendrids, whose impulses they must receive.

Continuity versus Contiguity of Nerve Cells.[1]

Professor A. S. Dogiel challenges the doctrine of strict anatomical independence of neurons. In the retina he finds not only anastomoses of the fine branchlets of the dendrids, but also a direct anastomosis of the cells themselves by means of a thick fibre. We reproduce in diagrammatic form one of his illustrations of the latter type.

The author concludes that in the retina, at least, the nerve cells constitute a colony of individuals all intimately bound together by means of their protoplasmic processes.

Fig. 7. Nerve cells from the inner ganglionic layer of the retina of man. Methyl blue preparation. a, an axis-cylinder process; b, protoplasmic processes: c, a process which unites the bodies of the two cells, from which pass out lateral branches, b'.

Intra-Cranial Pressure.[2]

The animals employed were cats or dogs. After a description of the methods of research, the following table of results is given:

1. The normal intra-cranial pressure scarcely ever exceeds 10 mm. Hg.

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[1] DOGIEL, A. S. Zur Frage über das Verhalten der Nervenzellen zu einander. *Archiv f. Anat. u. Phys.* Anat. Ab. 5-6, 1893.

[2] HILL, LEONARD. On Intracranial Pressure. Preliminary Note. *Proc. Roy. Soc.*, LV, 331.

2. The normal cerebral venous pressure in the dog is equivalent to 100—120 mm. water.

3. The pressure in the superior longitudinal sinus with the flow of blood obstructed rises to double or more the normal cerebral venous pressure.

4. The air index in the measuring apparatus exhibits perfectly the cardiac and respiratory undulations of the intra-cranial pressure.

5. The water manometer in connection with the venous cavity in the occipital protuberance, or with the longitudinal sinus, exhibits the cardiac pulsations and large respiratory undulations.

6. Salt solution (0.6 per cent.) can be slowly driven into the subdural space at the rate of about 1 c.c. a minute without raising the intra-cranial pressure or producing any physiological effects. As much as 20 c.c. has thus been driven in during one experiment.

7. Salt solution can be driven through from the parietal hole to a hole in the lumbar region of the spinal column. The whole of the subdural space can thus be syringed through.

8. Salt solution cannot be driven from a hole in the lumbar region out of a hole in the parietal region. The brain floats up and closes the parietal hole as a valve.

9. Salt solution, if driven in quickly with a higher pressure, produces a momentary rise of intra-cranial pressure and momentary physiological effects. These disappear very rapidly as the solution is absorbed.

10. On introducing 0.5 c.c. of salt solution within a bag in the sub-dural space of a cat, no rise of intra-cranial pressure occurs, and no physiological effects are produced.

11. The introduction of more than 0.5 c.c. produces a lasting rise of intra-cranial pressure and physiological effects. These are: (1) slowing to stopping of respiration; (2) rise of blood pressure and slowing of the heart; (3) dilatation, or extreme constriction, of the pupil, and some times nystagmus.

12. The cat may become habituated to the smaller degrees of heightened intra-cranial pressure, and the physiological effects pass off.

13. Greater amounts than 1 c.c. cause an enormous and maintained rise of arterial pressure, with acceleration of the heart, inspiratory gasps at long intervals, followed by fall of arterial pressure and death.

14. 0.5 c.c. is the largest amount of displacement which can be perfectly compensated for in the cat, *i.e.*, this is the reduction of the

cranial capacity which can be made up for by escape of cerebro-spinal fluid.

15. The brain of the cat of ordinary size, measured up to the level of the calamus scriptorius, equals in volume 26 c.c.

16. The amount of compensation is reduced to nothing on repeating the experiment a second time, and the effects which follow the introduction of the same quantity of salt solution into the bag are much more marked.

17. In the dog of the fox-terrier size the amount of compensation is 1.5 c.c.

18. The brain of the ordinary fox-terrier, on an average, equals 64 c.c. in volume.

19. The introduction of more than 1.5 c.c in the dog produces a lasting rise of intra-cranial pressure and physiological effects. These are the same as in the cat, except that there is no rise of blood pressure.

20. On cutting both vagi in the dog, the rise of blood pressure occurs as in the cat, and may reach enormous amounts.

21. The compensation is reduced to nothing in the dog on repeating the experiment a second time and the effects are much more severe.

22. The physiological effects can be immediately removed by emptying the bag, and the pressure in the intra-cranial cavity recovers its old standard.

23. If the displacement caused by the bag is large, and maintained for a considerable time, there may be no relief and no expansion of the brain on emptying the bag.

24. Trephine holes made in various parts of the cranium and vertebral column afford no relief to the effects produced by the bag.

25. No fluid is to be found within the subdural space after the "bag experiment." The surface of the brain and the cavity of the skull are quite dry.

26. After the "bag experiment," salt solution can no longer be absorbed, and can no longer be driven through to a hole in the lumbar region, but acts in the same way and produces the same effects as the bag.

27. Marked physiological effects occur in the cat when the intra-cranial pressure is raised 10 mm. Hg above the normal. The measurement is taken over the medulla oblongata.

28. The venous pressure in the cavity of the occipital protuberance falls to zero when the "bag" is distended over the parietal re-

gion, *i.e.*, the entrance of blood is obstructed; the exit by the bony transverse sinuses remains open.

29. The venous pressure in the superior longitudinal sinus rises when the "bag" is distended, *i.e.*, the exit is obstructed by the cannula, and blood is forced out of the tributary veins into the sinus.

30. The normal venous pressure in each case at once returns when the bag is emptied.

The capacity of the intra-cranial cavity can be diminished by the introduction of a foreign body into the subdural space. The first effect of the diminution is to expel the cerebro-spinal fluid. After its disappearance, further diminution of the space can only take place by equal diminution of the volume of the intra-cranial blood vessels, particularly of the veins and capillaries. *The* restriction or *arrest of the cerebral circulation thus produced is the efficient cause of the physiological disturbance* observed after diminution of the intra-carnial cavity.

In the animals experimented on, any considerable increase of the intra-cranial pressure above the normal (about 10 mm. mercury) interferes with or arrests the cerebral circulation.

On driving salt solution coloured with methyl blue into the subdural space at the rate of 1 c.c. a minute, the urine which was collected from one ureter became of a blue colour in from 15 to 30 minutes. On *post-mortem* examination, the upper portion of the first lymph gland in the cervical chain was found to be coloured blue; in the central nervous system the blue colour was found limited to the cerebral hemisphere on the side of injection, the base of the brain, and the cervical region of the cord. Conclusion—The blood vessels form the pathway of absorption of fluid from the subdural space.

Functions of the Cerebellum.[1]

The results detailed refer chiefly to dogs, but the effects of similar lesions of the cerebellum in monkeys are contrasted with these. The question as to whether the cerebellum exerts any trophic influence is separately considered, as is a case of defective development of the cerebellum in a cat.

The investigation of the excitability of the two cerebral hemispheres, as tested by the induced current, yielded results of more than ordinary interest, for, whereas the excitability was equal on the two sides when the cerebellum was intact, the opposite hemisphere

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[1] Russell, J. S. Risien. Experimental Researches into the Functions of the Cerebellum. *Proc. Roy. Soc.*, LV, 331.

was the most excitable after unilateral ablation of the cerebellum, which difference in the excitability persisted, and was still present even three months after the half of the cerebellum had been removed. The results obtained when absinthe was administered to animals which had been deprived of half the cerebellum also yielded highly interesting and instructive results. The increased excitability of the opposite hemisphere was evidenced by the exaggeration of the convulsions on the side of the cerebellar lesion; and it became also evident that the convulsions on the opposite side were diminished. Further, the curves obtained from the extensor muscles of the anterior extremity on the side of the cerebellar lesion showed that there was a marked alteration in the second stage of the convulsive seizure, for the tonus characteristic of this stage of similar convulsions evoked in dogs whose central nervous system was intact was either replaced by clonic spasms, or a large element of clonus was superimposed on the tonus. The curves from the muscles of both anterior extremities showed this alteration in the second stage of the convulsions when the whole instead of the half of the cerebellum had been previously removed.

The chief conclusions which appear to be warranted are that the one half of the cerebellum does not, in any great measure, depend on the coöperation of the other half for the proper performance of its functions. The bulk of the impulses pass from one half of the organ to the cerebrum, or spinal cord, without passing to the other half. Three factors are responsible for the defective movements which result on ablation of different parts of the organ—incoördination, rigidity, and motor paresis. The last of these is probably directly due to the withdrawal of the cerebellar influence from the muscles, while the exalted excitability of the opposite cortex cerebri, which results after unilateral ablation of the cerebellum, is probably a provision for compensation in this and and other connections. The one half of the cerebellum controls the cells of the cortex of the opposite cerebral hemisphere, and those of the anterior horns of the spinal cord on the same side chiefly, and on the opposite side to a slight extent. It is further suggested that either the cerebral hemisphere whose excitability is increased inhibits the opposite hemisphere, or that, under normal conditions, one half of the cerebellum inhibits the other half, which inhibition being no longer operative, owing to ablation of half of the organ, allows the remaining half to exert an increased control on the opposite cortex cerebri, or on the spinal centres of the same side, or possibly in both directions; but which is the most probable explanation of the phenomena observed is at present left an open question.

It is urged that, instead of looking on the cerebellum as a distinct organ which has a special function, distinct from those subserved by other parts of the central nervous system, it would be more correct to look on it as a part of that system, having many functions in common with other parts of it, the chief difference between one part of this great system and another being the degree in which different functions are represented in any given part: *e. g.*, with regard to motor power, the anterior extremity is maximally represented in the cerebrum and minimally in the cerebellum, whereas the trunk muscles are minimally represented in the cerebrum and maximally in the cerebellum.

Metamerism in Vertebrates.

Mr. Locy in a recent number of the *Anatomischer Anzeiger* (28 April, 1894,) calls attention to the fact that the division of the nerve cords into segments occurs much earlier than is generally supposed. He gives a careful description of the development of the nerve tube in Squalus acanthias, with illustrations of the more important stages in which he shows that this segmentation is one of the earliest phenomena to appear after the embryo is outlined. The embryonic rim he finds to be segmented not only before the closure of the medullary tube, but even before the medullary folds have appeared. This segmentation is primitively epiblastic, and is clearly defined throughout the length of the embryo before the mesoblast has, to any extent, become divided into somites. These segments have been traced directly into those of later stages and therefore they are not evanescent.

From a detailed study of the relations of these segments to the organs appearing later in the development of the embryo, Mr. Locy draws the following conclusion:—The segmentation of the neural axis is much older, historically speaking, than the division of the brain into vesicles. It is a much more primitive characteristic, and quite probably existed for great lapses of time before the latter arose. (The order of their appearance and the time interval between the two would indicate as much.)

We thus have exhibited the relation between two distinct morphological processes the one, the division of the embryo into segments, and the other, the modification of the head end into cranial vesicles. The former is already in existence when the latter process commences, and we have the cranial vesicles superimposed upon an already segmented neural axis. It seems to me, therefore, that we are not justified in going further than to say that there is a certain number of neural segments modified to form the head, and, after various shiftings of position and rearrangements of parts, there come to be, finally, two of the original segments included under the roof of the greatly expanded mid-brain, and three under the dorsal wall of the fore-brain. It is not, at bottom, primitive segmentation of the brain with which we are dealing, but primitive segmentation of the embryo; and the anterior end of the body undergoes the most extensive modifications, and departs most widely from the early segmented condition.

Reform in Anatomical and Descriptive Terminology.

Nothing more clearly demonstrates the necessity for reform in the cumbrous and ambiguous nomenclature of anatomy than the persistence with which various solutions of the problem are urged. It is fashionable in some circles in America to sneer at these attempts and to minimize the extent to which some of the reforms have been adopted, but it is noticeable that such animadversions do not come from those who have seriously struggled with the practical difficulties of descriptive anatomy. Professor Wilder's name is associated with a system which, in spite of what appear to many serious infelicities is yet the most consistent and complete yet formulated.

On the whole one can now see that the zealous advocacy and use of the system has had a profound influence. Curiously enough it is in Europe that his or similar suggestions are taking strongest root. The substitutes from time to time offered often serve to make the earlier system seem more desirable by contrast.

A recent article by Dr. Alpheus Hyatt[1] calls attention to the comprehensive attempt to revise descriptive terms recently offered by F. E. Schulze.[2] The terms of position and direction as applied to bilateral animals may be said to be reasonably settled, but in the case of Synstigmata or Centrostigmata having a single imaginary centre other difficulties are encountered. The central point is called the "centrum," points at the centre are centran, those near the centre are central, those which lie toward the centre are centrad or proximad; opposed to these terms are compounds of proximus. Any part at right angles to radii is tangential, if external, or paratangential, if internal.

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[1]Remarks on Schulze's System of Descriptive Terms. *American Naturalist*, XXVII, 329,

[2]Bezeichnungen d. Lage u. Richtung im Thierkörper. *Biol. Centralblatt*, XIII, 1, 1893.

We cannot go into details as to the application of this system to radially symmetrical and bilateral animal bodies, but agree with Professor Hyatt that in many respects the suggestions of Professor Wilder are more simple and serviceable.

Nerve-roots of the Muscles of the Throat and Palate.[1]

This article embodies the results of numerous experiments made upon cats, rabbits, and dogs. The value of the article is much enhanced by the discussions of the views of previous authors. Poverty of space forbids more than a brief mention of some of the author's conclusions.

The following conclusion, although founded upon experiments performed upon the lower mammals, it is thought can be applied to man. *N. trigeminus* gives fibres to the *M. tensor veli palatini.*

N. facialis gives motor fibres to *M. levator veli palatini* and *azygos uvulæ.*

M. glossopharyngeus gives motor fibres to *M. stylo-pharyngeus.*

N. accessorius. The experiments upon this nerve are not so reliable as the others, owing to difficulties of investigation. Irritation of the lower bundle causes no muscular movements of either the throat or the soft palate. The muscles which diminish the cavity of the throat (the constrictor, *M. palato-pharyngeus*, *M. palato-glossus*, *M. levator veli palatini*) are innervated from the superior fibres of the middle bundle. The muscles that increase the throat-cavity (*M. stylo-pharyngei*) are innervated by the superior bundle.

C. H. T.

Innervation of the Pharynx.[2]

Dr. Réthi's paper on the roots of the motor nerves of the pharynx is followed by an exact determination of their peripheral distribution. After exposing the muscles and nerves of this region in a narcotized animal, the nerves were electrically stimulated, and their connections thus accurately determined.

The motor fibres of the M. stylo-pharyngeus pass over into the vagus trunk while still within the foramen jugulare and pass to their destination as branches of the R. pharyngeus vagi.

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[1]Rethi, L. Die Nervenwurzeln der Rachen- und Gaumen-muskeln. *Sitzungsberichte d. k. Akademie d. Wissenchaften, Wien.* Bd. CI. (1892), p. 381-420.

[2]Rethi, L. Der periphere Verlauf der motorischen Rachen- und Gaumennerven. *Sitzung. der kais. Akad. der Wissenschaften, Wien.* CII, 3-7, 1893.

The M. levator veli palatini is innervated from the lower fibres of the middle root-bundle (not from the upper fibres as stated in the earlier paper). In their peripheral course these fibres maintain their union with the vagus, passing out as the upper twig of the R. pharyngeus vagi. They are not associated with the accessorius, as stated by Beevor and Horsley.

The nerves for the constrictors of the throat arise in the middle root-bundle and pass out in the R. pharyngeus vagi. Those for the M. palato-pharyngeus constitute the middle part of the lower division of the same ramus, while those for the M. palato-glossus pass out in its upper division.

The studies were made on dogs, cats, rabbits, Macacus, etc. Both this paper and the earlier one are accompanied by copious bibliographical citations.

Association-bundles of the Cerebral-mantle.[1]

The *fibræ arcuatæ* of the mantle rest upon an oblique layer of longer association-bundles.

The *fasciculi uncinati* are but the anterior portions of a system of association-bundles which extend from the cephalic end of the mantle, above the sylvian fissure into the parieto-occipital and temporal regions of the mantle.

The radiations of the *fasciculus arcuatus* are but a superficial continuation of the association-bundle which begins in the transition convolution (übergangswindung) of the medulla and curves around the sylvian fissure into the cerebrum. From it fibres branch to the parietal, occipital and temporal regions.

Through the medium of the anterior commissure there is a decussating association of the olfactory with the occipital cortex.

Through the union of the *fasciculus arcuatus* with the lower layer of the oblique bundles of the callosum all those cortical regions which are associated through the medium of the *fasciculus arcuatus* are connected by the callosum with some not-yet-determined portion of the other hemisphere.

Two facts, at least, militate against the assumption that by means of the callosum physiologically similar portions of the two hemispheres are forced to function simultaneously: 1st, the centers for speech and

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[1]THEODOR MEYNERT. Neue Studien über die Associationsbündel des Hirn mantels. *Sitzungsberichte d. Kaiserlichen Akademie der Wissenschaften, Wien.* Bd. CI. (1892) p. 361-379; Taf. I-IV.

writing are located in one hemisphere only; 2nd, morphologically similar portions of the body may simultaneously perform physiologically dissimilar acts.

C. H. T.

The Brains of Microcephalic Idiots.[1]

Professor Marchand's studies were made upon three microcephalic brains, which, for convenience I will name brains I, II and III.

No. I was the brain of Carl Koch, a boy four years and ten months old. Weight of brain, including the membranes 890 g. Length 15.5 cm.

No. II was the brain of a man 40 years of age. Weight of brain, including membranes, 870 g. Weight excluding membranes, 603 g. Length of right hemisphere 13 cm. Length of left hemisphere 13.3 cm.

No. III was the brain of Augustin Heil, age 33 years. Weight of hardened brain 424 g. Length of the right hemisphere 11.7 cm. Length of left hemisphere 11.6 cm.

These investigations establish a number of interesting facts:

1. Compared with the normal human brain, these microcephalic brains are very small, brain No. III, being only about one third as heavy as the average male brain. Indeed this brain is but a very little larger than that of a gorilla or a large sized chimpanzee.

2. There is a great tendency to simplify and obliterate convolutions.

3. The central fissure tends to become *vertical,* indeed in No. I and II it has fused with the sylvian fissure.

4. In two cases the isle of Reil is exposed. This is a reversion towards the type found in the lower apes.

5. In brain I, the rudimentary condition of the 1st and 2nd occipital convolutions reminds one of the brains of the lower apes.

6. The abnormally constructed diminutive occipital lobe, bears a more or less developed *operculum occipitale.*

7. In brains II and III there is a marked foreshortening of the callosum.

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[1]Felix Marchand. Beschreibung drier microcephalen Gehirne. *Nova Acta d. Ksl. Leop.-Carol. Deutschen Akademie.* Bd. LIII, No. 3 (1889). Bd. LV, No. 3, (1890).

8. In brain I: a.—There is an enormous increase of the grey matter at the expense of the white. This peculiarity is especially noticeable in the parietal lobes and in the anterior portion of the central convolution. This is accompanied by an enormous development of the ventricles. b.—The *fissura calcarini* fuses with the *sulcus ammonis.* c.—The grey matter of the olives is so subdivided as to resemble numerous accessory olives.

9. In brain II: a.—The *fissura parieto-occipitalis* is continued into the *sulcus occipito-transversus.* b.—There is a pronounced diminution of the cuneus.

10. In brain III the structure of the parieto-occipital fissure is abnormal.

C. H. T.

Notes on the Frontal Lobes and the Isle of Reil of Anthropoid Apes.[1]

The following is a partial list of the subjects used in these investigations:

Chimpanzee No. I. A young female with twenty milk teeth. Length of cerebrum, 9.3 cm.; height, 4.6 cm.; breadth, 8.2 cm.

Chimpanzee No. II. Brain of an adult female. Length of cerebrum, 9.5 cm.; breadth, 8.2 cm.

Chimpansee No. III. Brain of male. Length of left cerebral hemisphere, 8.7 cm.; length of right cerebral hemisphere, 8.2 cm. breadth, 8.7 cm.

Chimpanzee No. IV. Length of cerebrum, 10 cm.; breadth, 9.0 cm.

Brain of male gorilla. Length of hemisphere, 10 cm.; breadth, 9.0 cm.

Brain of female orang. Length of right hemisphere, 8.6 cm.; length of left hemisphere, 9.0 cm.; breadth, 8.6 cm.

It will be noticed that these brains, especially those of the gorilla and chimpanzee IV, approach in size the brains of microcephalic idiots. It will be noticed also that one hemishere is often much longer than the other. This is the case in the brains of microcephalic idiots.

1. *Sulcus præcentralis.* In its most highly developed from this sulcus is divided into a superior, an inferior and a median portion. In chimpanzee II right, gorilla left and orang VI left,[2] all three of these

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[1]FELIX MARCHAND. Die morphologie des Stirnappens und der Insel der Anthropomorphen. *Jena*, 1893, 108 pp., 3 plates. Monograph.

[2]The roman numerals refer to the number of the specimen. The words "left," "right," "both," refer to the side of the hemisphere.

fissures are present; in gorilla right and orang I right, the superior division is either absent or rudimentary, while in orang II right all three fissures are fused into one.

2. *S. frontalis superior.* In most cases [gorilla right, chimpanzee I-IV both, orang Ia left, orang Ib right, orang VI both] this fissure proceeds from the *s. præcentralis superior* Occasionally when the præcentralis is obliterated, this fissure may either extend near to [Orang IIa left] or penetrate [gorilla left, orang Ia right, orang Ib left] the cen; tral fissure.

3. *S. frontalis inferior.* This fissure proceeds from the lower *fissura præcentralis.* It may be feebly developed [chimpanzee I left, chimpanzee III both, gorilla left, orang I right, orang IIa both] or rudimentary [orang VI right] or absent [orang VI left] or fused with the *s. rectus* [gorilla right, chimpanzee I and II right chimpanzee IV both.

4. *S. frontalis medius.* This is present in all [chimpanzee I and II left, chimpanzee III both, orang I right, orang Ia right, orang Ib and IIa both.] It arises from the *s. præcentralis.*

5. *S. rectus.* This is present in all. It is identical with the oblique frontal fissure of human anatomy.

6. *S. fronto-orbitalis.* This is present in all.

7. *S. orbitalis.* This fissure is feebly developed. It is more highly developed in the gorilla than in any other ape.

8. Usually this fissure is short [chimpanzee I, III, IV, orang] occasionally it reaches almost to the anterior extremity of the cerebrum [chimpanzee II, gorilla.]

9. *S. opercularis.* This is found on the lower surface and is straight.

10. *S. subcentralis anterior.* This is quite constant.

In both the chimpanzee and the gorilla, the three frontal convolutions have all the distinctive characteristics of the human frontal convolutions.

The *gyrus orbitalis lateralis* is identical with the orbital portion of the third frontal convolution.

There are two fissures (*S. opercularis* and *fronto-marginalis*) connected with the sylvian fissure of the apes, for which no homologues can be found in the sylvian fissure of man. This fissure differs from the human in passing unobstructedly into the *operculum superius.*

The *operculum frontale* of human anatomy is missing.

The orbital fissures of the gorilla and chimpanzee resemble the same human fissures.

In the lower apes the isle of Reil is exposed. This is also the case in microcephalic idiots. We have not sufficient morphological data to warrant the identification of the sylvian fissure of the apes with the so-called sylvian fissure of the carnivores.

The absence of a physiological activity does not necessarily involve the absence of that portion of the brain in which the seat of the function is usually located. That portion may have assumed some other function.

Since the power of speech is absent in many men without apparent alteration in the "speech-centre," we may not derive morphological conclusions from the lack of speech in animals. For the exact determination of the physiological homologies between the brain of man and apes, further experimental work is desirable.

In the cerebral topography the chimpanzee resembles man more closely than does the orang.

C. H. T.

The International Journal of Microscopy and Natural History.

We are glad to notice a marked improvement in this well-known periodical which bids fair to become one of the most generally useful of its class. In addition to the popular matter there is an increasing number of technical papers of permanent value. The notes on histological methods are often valuable and the critiques and book notices are full. It is noticeable that many Americans are among the contributors.

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LITERARY NOTICES.

Three New Psychologies.

In spite of obvious and serious defects, Alfred Binet's Introduction to Experimental Psychology[1] is well adapted to put into the hands of the student as an introductory collateral text-book, as well as for the general public for whom it is obviously written. It will do much not merely to popularize the subject, but to correct many erroneous notions now afloat as to the real scope and method of Experimental Psychology, while, on the other hand, the incomplete and unsymmetrical character of many of the sections may foster other errors equally grave. The following quotations will show the standpoint from which the work is conducted. Speaking of the relation between Psychology and Metaphysics on the one hand and the physiology of the nervous system on the other hand, he says, "Our subject has one characteristic which, well understood, will prevent all confusion. Introspection (inner sense, consciousness, etc.) is the basis of Psychology; it characterizes Psychology in so exact a manner that we may say that any study which is carried on by means of introspection may be called psychological, while those employing other methods belong to other sciences." Of course the word introspection is used in the broad sense. Again, at the close, he urges that the Experimental Psychology of today is a pure natural science and nothing more. While independent of Metaphysics it does not exclude such researches.

The first chapter is devoted to psychological laboratories and contains a full description of his own laboratory at Paris and of the German laboratories. He enumerates several of the American laboratories but lacks detailed information of their organization. The recent papers of Varigny in the Revue Scientifique and of Baudoiun in Les Archives de Neurologie will, we trust, supply this deficiency in part.

As to methods, observation is ranked as correlative with experiment, though relatively small space is given to it in the text; and in

[1] Introduction à la Psychologie Expérimentale by Alfred Binet with the collaboration of MM. Philippe, Courtier and V. Henri. *Paris, F. Alcan*, 1894.

general those methods requiring simple apparatus or none at all are treated more fully than the more intricate studies in which refinements of precision are aimed at. This is in accord with the author's repeated statement that these latter methods, so assiduously cultivated in Germany, though extremely accurate and delicate and though reaching great simplicity in the results by the elimination of all individual differences, yet often have the defect of reducing the reacting subject to a mere automaton and thus losing the most valuable results which should follow from such experiments by confining the research within the circle of the preconceived idea. The author's practice is to have the subject in the same room as the operator and to encourage him to close self-observation during the entire course of the experiment and at the close to express his mental states fully and not by arbitrarily limited symbols. Many valuable truths have thus been unexpectedly brought to light. It seems to us that he here confuses two very distinct points of view. We do indeed often try an experiment merely "to see what comes of it;" but any result which may be obtained in this way is by no means an established fact until it has been repeatedly verified and substantiated by that very method of painstaking elimination of the variable factors in which the German psychologists are so proficient. Both methods of research are required, for each will supplement the other. The author certainly does well to emphasize the highly artificial character of the conditions in the ordinary laboratory experiment and to insist on the reduction of this element of error to the minimum.

Psycho-physics is treated respectfully, but rather conservatively. The chapter on psychometry is rather more full and includes a description of the Hipp chronoscope. But little space is devoted to descriptions of apparatus or the details of experiments. Those which are cited are merely for the purpose of serving as illustrations of general principles. Anything like abstruseness, either of matter or treatment has been avoided and the book is very readable throughout.

A work of a very different character is Dr. Sanford's Laboratory Course in Psychology.[1] This brochure of 183 pages comprises advance sheets merely of the contemplated work and includes a portion of Part I. This portion of the work is based on the course published in The American Journal of Psychology (1891-1893). Some additions have been made and a few other changes, but in the main the

[1] SANFORD, EDMUND C. A Course in Experimental Psychology. *Boston, D. C. Heath & Co.*, 1894.

treatment is the same. The author's statement made in the introduction to the articles just mentioned (April, 1891) that "Just what experiments such a course should contain is itself as yet a matter of experiment" is still true perhaps but certainly not to the same extent as then. This series of experiments, at least, has stood the test of several years of practical use; and the psychological laboratories so rapidly springing up in all of our best colleges emphasize the necessity for such a manual, adapted to the needs of undergraduate students rather than for advanced research courses. With this apparently in mind the author has selected for the most part subjects suitable for demonstration before a class or for rapid individual verification, rather than problems involving elaborate experimental and inductive processes. So also simple apparatus is employed wherever possible. In fact, one of the most practical features of the book is the skill displayed in directing precise experiments with the use of simple pieces, most of which can, if necessary, be made by the instructor himself. Another feature of the greatest helpfulness is the full citations of literature found at the close of each chapter. The 169 experiments outlined are all on the senses and are chiefly qualitative determinations rather than exact quantitative measurements.

Professor William O. Krohn's "Practical Lessons in Psychology"[1] is one of the volumes in The Working Teacher's Library and well deserves a place in the hands, not merely of every public school teacher, but of the hundreds of other people who desire to see the practical applications of what is newest and best in the "new Psychology" clearly set forth without formality or unnecessary technicality. Most of the chapters are based on lectures delivered before various gatherings of teachers and to this is due not only the fresh and colloquial style and studied simplicity, but also a certain element of diffuseness and repetition. We very rarely find a book which so successfully meets the requirements of the general non-technical public and at the same time comes into touch so closely with the original sources. It is thoroughly up to date and the author seems to have swept the whole horizon of psychological research until the very day of publication. Comparative psychology is duely recognized and the treatment of child-psychology is especially full and practical. In fact every page fulfils the promise made at the start "that the book shall be characterized by a practical ring rather than a scholastic rattle."

C. J. H.

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[1] Chicago, The Werner Company, 1894.

Direct Control of the Retinal Field.

Professor Ladd under this title cites some noteworthy cases in the July number of The Psychological Review. He himself is able by attentively willing for perhaps some three to five minutes to cause a cross, or a circle, or two concentric circles, or some other simple figure, to appear in the retinal field. He also found upon addressing the question, "Can the retinal sensations which arise with the eyes closed and motionless be made to respond to volition with respect to the form and color which they assume?" to a class of sixteen advanced students in Psychology, that four reported no success, nine had a partial success which seemed to increase with practice, and with the remaining three the success was marked and really phenomenal. He concludes that we have here an experimental demonstration of the unique and inexplicable power of the volition of the ego to induce changes in the cerebral centres and the connected organs of sense—and in this case, apparently, without any use of the muscular system to control the nature of those changes.

Psychology of Touch.[1]

The first study was directed to the Education of the Skin with the Æsthesiometer and lead to positive results in line with those of Volkmann. A second series of experiments was made on open and filled space for touch using the method of Professor James, i. e., by passing the finger along lines on paper which had been bisected, one half having been roughened by punctures through the paper. The tests, which were varied in many ways, led to the general result that the closed space was judged the longer. The psychological conclusion reached is "that if we have given two trains of sense-perception produced in the mind in equal duration of time, the one which is made up of the greater number of distinct sensations requires of the mind a greater amount of space in its reference to the external world." Then follows a very interesting study on Illusion for Weights, a Study in Association and Apperception. Eight hollow brass weights were made varying from 1½ to 5 inches in length, which were each made to weigh 132 grams by filling with different substances. To external appearance they were exactly alike except in length. In the numerous experiments on school children and adults the subjects were told to "arrange them in order of their weight." In the majority of cases

[1] DRESSLER, F. B. Studies in the Psychology of Touch. *Am. Jour. of Psychology*, VI, 3, June, 1894.

the weights were arranged in the *exact* order of their size. The smallest weight was on the average judged three times heavier than the largest. A different set of subjects estimated the smallest to be 2.4 heavier, on the average, than the largest if only these two extremes were presented to them. Again eight weights were made of sheet lead all of the same area and weight but varied in shape from a circle to an irregular cornered figure. The weights which appear smaller, that is, are of a compact form, were judged to be heavier than those not so compact. The author concludes: (1) The more intelligent the children, other things being equal, the stronger are the associations between the ideas of size and weight of a given material. (2) The stronger this associative element becomes, the more likely it is to dominate and pervert the true sensations, when the conditions are such that these associations do not hold. (3) The elements the mind furnishes, keeping these conditions, have far more influence in determining the judgement than the sensations directly received. (4) Illusions are easily built up when suggested along the lines of firmly fixed associations. (5) Consequently the brightest children are more suggestible under these conditions than the dullest ones. (6) The method used in this research furnishes a means of measuring suggested illusions of this type. (7) Adults have stronger associations between the ideas in question than children, and, despite the fact that they have a higher degree of sensibility for difference in weight, their sensations are more transformed and influenced by the element which the mind itself furnishes than are those of children. (8) Facts which vary, within limits, from our established habits of apperception are simply not taken account of at all; or, if on some occasion the conditions force us to see how our minds have become insulated against the reception of different relations, we do so with a wholly new feeling of personal fallibility. (9) The pedagogical significance of the facts emphasized in this research is of the utmost importance. It has to do with one of the most fundamental laws which regulate our mental life. The foregoing tests as a whole show how strong and dominating an association between ideas may become when they are practically unseparated and immediate in their sequence.

The Care of the Insane.

In the July number of the Journal of Nervous and Mental Disease appears Dr. S. Weir Mitchell's "Address before the Fiftieth Annual Meeting of the American Medico-Psychological Association," delivered last May. Speaking to the representative medical superintendents of the nation's Insane Hospitals, Dr. Mitchell urges in a kind but fearless manner some of the abuses of our present asylum management. His positions are supported by letters from some thirty of the ablest neurologists and consultants of our larger cities and the text of many of these letters appended to the published discourse comprises by no means the least instructive part of the article. No one, whether physician or layman, who really has at heart the interest of the thousands of insane confined like criminals in that absolute idleness which would soon prove fatal even to a sound mind in the crowded wards of our large asylums (they are often not "hospitals") can afford to allow this address to pass without at least a careful reading. The responsibility for many of these abuses must rest with the managing boards and the political dictators behind them. Economy of administration seems to be the criterion by which all excellence is gauged; hence it is that the "Medical Superintendent" is too often more of a business manager than of a physician; hence also the immense structures in which the patients are quartered instead of cottages so constructed as to admit of the most perfect classification, the terrible crowding of patients into great dreary wards with barred windows and locked doors with perhaps only two attendants to a hundred patients, the attendants themselves mere overseers designed to keep order rather than trained nurses qualified to assist the overworked physicians in the arduous task of treating daily hundreds of cases of the most difficult nature known to medical science.

As correctives, the most urgent are the utter divorcement of the management from politics and the appointment of business managers whose duties shall have nothing whatever to do with those of the physician in charge. This will leave the latter time to attend to his legitimate duties, in which he should have the constant assistance of consulting physicians from outside. It is also very encouraging to note that these neurologists, all of them immersed in the practical duties of a large practice, with singular unanimity urge that the physician in charge must be an investigator and that his whole institution must be charged with the spirit of active investigation. Every physician down to the intern, even to the nurse, should be somewhat of a neurologist and a psychologist as well. In this way alone can the professional life of the hospital be kept above the low water mark, to say nothing of the fact that the vast scientific possibilities now heedlessly ignored in nearly all of our great asylums would thus be saved to science.

Of course it must be borne in mind that these abuses do not exist in all of our public asylums, that where they do occur the fault lies largely with the board of control and their constituents rather than with the physicians and that the heroic attempt to introduce more modern methods of treatment and research often meets with obstacles which sometimes amount almost to persecution. This Dr. Mitchell would probably freely grant, though there are some sweeping passages in his address in which it is apparently lost sight of.

C. J. H.

Audition Without the Labyrinth.[1]

A dove whose labyrinth and tympanum had been previously destroyed on both sides reacted to auditory stimuli just like another animal whose peripheral sensory apparatus was normal, except that for tones above 440 vibrations no positive results, or only doubtful results could be obtained. Some tone-qualities, at least, could be distinguished.

Alterations in Nerve Cells from Birth to Old Age.[2]

Sections of the first cervical ganglion of a still-born babe (osmic acid preparations) compared with similar sections from a subject who died at 92 years of age show that in the latter case the nucular granules do not stain with osmic acid; that the nuclei are shrunken in size, have irregular contours and (unlike fatigued nerve cells) stain no darker than the cytoplasm. Sections of the nervous system of young and old bees give much more emphatical testimony to the same alterations. The number of cells is also greatly reduced in the old specimens. A fuller paper with plates is announced for The Journal of Physiology.

A New Cranial Nerve in Protopterus.[3]

The author describes a nerve hitherto undescribed arising near the median line on each side immediately ventrad of the anterior commissure at the extreme cephalic limit of the "recessus praeopticus" of Burckhardt. The nerve is non-medullated and very small. It

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[1] WUNDT, WM. Akustische Versuche an einer labyrinthlosen Taube. *Philos. Studien*, IX, pp. 496-509.

[2] HODGE, C. F. Die Nervenzellen bei der Geburt und beim Tode an Alterschwäche. With 4 figures. *Anat. Anz.*, IX, 23, 1 Aug., 1894.

[3] PINKUS, FELIX. Ueber einen noch nicht beschriebenen Hirnnerven des Protopterus annectens. Vorläufige Mitteilung. *Anat. Anz.*, IX, 18, 23 June 1894.

courses forward, penetrates the firm connective tissue behind the nasal capsule, then rises and is applied more or less closely to the most medial bundle of the olfactorius, with which, however, it does not anastomose and from which it can be easily distinguished by its texture. It terminates in a cellular aggregation at the extreme end of the nose on the dorsal wall of the external nares. The internal course is not stated in this notice.

Free Nerve Termini in the Epithelium of Lumbricus.[1]

Both Lenhossèk and Retzius after the most exhaustive study affirmed that free nerve termini do not occur in the skin of the earthworm. Dr. Smirnow, however, finds by a modification of the rapid Golgi process very numerous, extremely fine, usually varicose free termini in the epithelium of the skin and the mucous membrane of the mouth cavity and oesophagus. The accompanying diagram, copied from one of the author's, presents a typical arrangement.

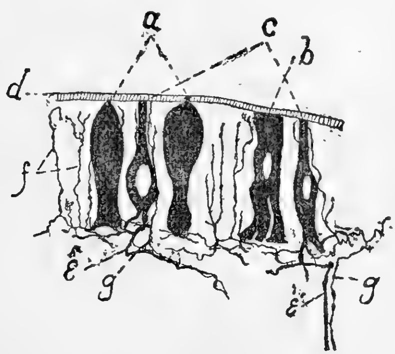

Fig. 8. Skin of Lumbricus. a, mucous cells; b, supporting cells; c, nerve cells; d, cuticle; e, axis cylinders from Lenhossek's cells; f, g, intra-epithelial fibres.

Degenerations of the Brain and Spinal Cord.

Two papers abstracted in the *Proceedings of the Royal Society* (March 1, 1894) contain much of value for the anatomist and the surgeon.

The first,[2] as a result of excision of the foci for the movements of the thumb and hallux from the cortex of the monkey, presents the following conclusion: It seems probable that a second decussation lower down in the cord—recrossing—does not occur, and that the bilateral degeneration observed by Pitres, Sherrington, Langley, Mura-

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[1] SMIRNOW, ALEXIS. Ueber freie Nervenendigungen im Epithel des Regenwurms. *Anat. Anz.*, IX, 18, 23 June, 1894.

[2] MELLUS, E. L. Preliminary Note on Bilateral Degeneration in the Spinal Cord of Monkeys (*Macacus sinicus*) following Unilateral Lesion of the Cortex Cerebri.

toff and others is a genuine bilateral descent of fibres from one hemisphere.

The second paper[1] presents the following conclusions from the study of extirpations and other experimental lesions performed on over 60 cats:

The formation of the descending system of the anterior, anteriolateral and lateral columns can be seen in the mesencephalon.

There is a marked decussation of the lateral and anterio-lateral column fibres in the mesencephalon. The anterior column fibres (post.-longitudinal bundle) appear to be direct fibres. Decussation is, however, not limited to this region; it occurs throughout the bulbospinal system.

Decussation of the pyramidal system is not limited to the cervical region; it occurs in the higher segments. As in the preceding system, so in this, there is a direct path—the direct lateral pyramidal tract, and there is evidence of direct fibres in the higher segments.

There is bilateral distribution of both systems of fibres, but there is no evidence whatever of recrossed fibres.

No fibres get into the opposite pyramid by way of the corpus callosum.

Stimulation with absinthe shows that the bulbo-spinal centres (including the cerebellum) alone, can produce a series of clonic fits, differing from the cortical in the much slower rhythm of the contractions. But from the complete section of the cord experiments it seems improbable that the cord alone can be excited by absinthe.

The author concludes that the maximal effect of absinthe is produced when the motor area is present, and that the impulses generated there are distributed by the pyramidal system in the way described, the maximal effect crossing to the opposite side, the question of unilaterality or bilaterality being one of degree as shown by the differences between the initial and the subsequent fits, and as borne out by the relative sizes of the crossed and uncrossed tracts.

The epilepsy due to absinthe indicates that there are probably very many epileptiform attacks in man which are toxic.

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[1] BOYCE, RUBERT. A Contribution to the Study of Descending Degenerations in the Brain and Spinal Cord, and of the Seat of Origin and Paths of Conduction of the Fits in Absinthe Epilepsy.

A Rapid Modification of Weigert's Method.[1]

Dr. Azoulay has devised a modification of Weigert's method of staining for which he claims excellent results and very great economy of time. It is applied to the axial nervous system as follows:—Harden three or four months in bichromate, or little pieces more rapidly in a mixture of bichromate of potash 3 per cent., 100 parts, and osmic acid 1 per cent., 25 to 30 parts; imbed in paraffine (or collodion or any other suitable medium); section in 90 per cent. alcohol; free the sections of paraffine with xylol or benzine; treat with absolute alcohol; apply Schweitzer's reagent (ammoniacal cuprous oxide undiluted) three to five minutes according to the thickness of the sections; wash by agitating in distilled water about 30 seconds; treat with hæmatoxylin (1 part to 10 of alcohol and 90 of water) either several days old, or fresh and treated with a drop of saturated solution of carbonate of lithium, or merely ordinary hæmatoxylin with alum, three to six minutes according to the thickness of the sections; the sections are to be heated on the slide while bathed in the stain to 60° (pass the slide over a flame until it steams, repeat the heating three or four times, taking care that the preparation floats in the fluid free from the slide); wash in water; treat with Weigert's decolorizer, prussiate of borax, 5, 10, 15, or 20 minutes according to the temperature employed and the thickness of the sections; arrest the decoloration when the large cells have only their nuclei colored a very dark brown; wash carefully in water; mount in acetone and balsam in benzine or xylol. The decoloration is so slow that one can be secure from decolorizing more than is necessary. The sections keep at least two years and a half.

Course of the Fibres from the Striatum[2].

In 1887 Dr. Edinger showed that in all vertebrates a thick bundle arises from the striatum, passes caudad to the thalamus where a part ends in a large nidus, while the remainder extends still further caudad. One bundle of the latter passes to the regio infundibuli, the course of the remainder was not determined. To solve this question three methods were employed, which gave concordant results; (1) the

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[1] AZOULAY, L. Méthode de coloration de Weigert rapide et transparente. *Bul. Soc. Anat. de Paris*, 5 Ser., VIII, 10, 1894.

[2] EDINGER, L. Die Faserung aus dem Stammganglion Corpus Striatum. Vergl.-anat. und experimentell untersucht. *Verhdl. Anat. Gesellschaft*, May, 1894.

study of serial sections of reptilian brains, (2) the section of the bundle in the pigeon and subsequent study by Marchi's method, this study being supplemented by that of two of Professor Goltz's dogs one of which had lost the cerebrum, the other both the cerebrum and the striatum of one side, (3) the study of a great number of Golgi preparations of reptilian brains to discover the character of the termini. In the alligator fibres from the striatum terminate in the thalamus in the following cell-clustres: (1) ganglion anterius thalami, characterized as the point of origin for Viq d' Azyr's bundle to the mamillare, (2) the great nucleus of the thalamus, so prominent in all reptilian brains and differently named by various authors, (3) the nucleus diffusus thalami lying between the two former, (4) the nucleus medius (?). The corpus geniculatum laterale receives no such fibres. The Golgi method shows that these fibres break up for the most part into terminal brushes which envelop cells, though there is reason to believe that some fibres arise from cells in the thalamus and pass in the opposite direction.

The experiments on the pigeon lead to the same general conclusions, as also do the dogs operated on by Professor Goltz. From the study of the dog without cerebrum but retaining the striata Dr. Edinger concludes that the capsula interna consists of at least three kinds of fibres; (1) from the cortex to the thalamus, (2) from the cortex to the pons and pyramids, (3) from the caudate and lenticular nuclei to ganglia of the thalamus and mesencepalon. The latter can in no case be traced beyond the mesencephalon and are always of finer calibre than those of the two former classes. The fibres of the ansa lentiformis (Linsenkernschlinge) and from the nucleus caudatus correspond to the basal prosencephalic bundle of the lower vertebrates. In the case of the dog deprived of both the cerebrum and the striatum all of these fibres were degenerate.

General Conclusion. The basal ganglion of vertebrates (in mammals divided into nucleus caudatus and lentiformis) originates a strong fibre system, the basal prosencephalic bundle. This terminates in the ganglia of the mesencephalon only. The nuclei of the thalamus and of the regio subthalamica are by means of these fibres united most intimately with the cerebrum. No fibres pass from the basal ganglia farther caudad than the substantia nigra Sömmeringi.

The name *Radiatio strio-thalamica* is proposed for this newly discovered, but phylogenetically very ancient fibre system.

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LITERARY NOTICES.

Regis' Manual of Mental Medicine.[1]

This is a prize volume, the first edition having been crowned by the Paris Faculty of Medicine in 1886. With the author, we recognize in this translation another step in the movement now so rapidly culminating which shall give us a true international science of psychiatry instead of the more or less discreet fragments which now go by that name in each of the several countries. It is true that psychiatry will in the nature of the case always present a certain local coloring dependent upon the phase of civilization which furnishes its materials; yet the existing situation in which each country has its own school of mental medicine and adheres to so great an extent to its own lines of psychical research betrays an insularity which is hardly compatible either with sound theory or successful practice. The volume before us may be taken as a fair exponent of the present situation in France. The first 28 pages are devoted to a historical sketch of mental pathology, after which follows a detailed consideration of the general pathology of mental alienation, occupying nearly 500 pages. The first two chapters are devoted to general considerations, the third to classification. The author introduces this chapter with the malicious remark of Buchez, "When they think they have finished their studies, the rhetoricians construct a tragedy and the alienists a classification," and then proceeds to develop an entirely new scheme of his own. We quote his summary at considerable length.

"I. The conditions of mental alienation are susceptible of being divided into two great classes: (1) functional alienations or insanities; (2) constitutional alienations or degeneracies.

"The insanities subdivide into two groups: (1) generalized insanities; (2) partial insanities. The generalized insanities comprise in their turn three genera: (1) mania (species: subacute, acute, hyperacute, chronic, remittent and intermittent mania); (2) melancholia (species: subacute, acute, hyperacute, chronic, remittent and inter-

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[1]Regis, E. A Practical Manual of Mental Medicine. Authorized translation from the second French edition by H. M. Bannister. *Utica, N. Y., Press of Am. Jour. of Insanity*, 1894.

mittent melancholia); (3) insanity of double form (species: continuous and intermittent double form insanities). The partial insanities have only one genus; systematized progressive insanity, composed of three stages or species: (1) hypochondriacal insanity; (2) persecutory, religious, political, erotic, jealous, etc., insanities; (3) ambitious insanity.

"The degeneracies subdivide also into two groups: (1) degeneracies of evolution or vices of psychic organization; (2) degeneracies of involution or psychic disorganizations. The vices of organization include four genera: (1) disharmonies (species: defect of balance, originality, eccentricity); (2) neurasthenias (species: fixed ideas, impulsions, aboulias); (3) phrenasthenias (species: delusional, reasoning, instinctive); (4) monstrosities (species: imbecility, idiocy, cretinism). The psychic disorganizations include but one genus: the dementias, which are also summed up in one species, simple dementia.

"II. There are no primary states of mental alienation other than the preceding. All other insanities do not exist as distinct entities. They are nothing but associations of a generalized simple insanity, mania or melancholia, with some physiological or pathological process in the organism."

The remainder of part I consists in the separate consideration of these species, and their secondary derivatives, their etiology, symptomology, progress, diagnosis, treatment etc. Part II is devoted to the Applications of Mental Pathology to Practice. In the chapters devoted to diagnosis, medical estimation of the necessity of sequestration, treatment in asylums and in homes, the key note is set by the word tact. Infinite patience, skill and perfect self-control are repeatedly urged and insisted upon. Moderate in all things, the author does not yield to the tendency now prevailing in some quarters to abolish mechanical restraint altogether, but urges its careful and humane application in some cases as a measure of real curative value. Besides the chapters on general curative agents, ten pages are devoted to therapeutic formulæ.

The chapter on the hereditary features of insanity contains much of practical value and reproduces some of the conclusions reached in the book on the biological characters of the families of the insane, of which M. Regis is joint author with Professor Ball. The section on Medico-Legal Practice refers largely to French law and a considerable portion has been omitted in the translation. The translation appears to have been conscientiously performed.

C. J. H.

La Famille Nevropathique.[1]

Under this title Dr. Féré has presented a systematic account of the great family of neuropathies with especial reference to teratology and degeneracy and the elements of heredity involved in each. Besides summarizing the chief points of value in the numerous technical papers upon these subjects, from the pen of this prolific author the work will be of the greatest value to students by reason of the very full citations of literature under every topic discussed.

The first chapter is devoted to a brief consideration of the general laws of heredity and of the theories of Weismann in particular. In the next six chapters the role of heredity in the various neuroses and psychoses is discussed in detail. Mental alienation, crime, genius and eccentricities in general are regarded as intimately related and the inheritance may, and commonly does, pass from one to another of these classes by substitution. The fact that these affections in the hereditary transmission do not run true to the several varieties but substitute very freely is not considered by Dr. Féré as evidence that they are not genetically related. While resemblance of parent and offspring is the rule in normal, progressive heredity, yet in morbid or degenerative heredity the converse is true, for this extreme variability is the most characteristic index of a dimunition of the vitality of the race or variety. The coincidence of nervous diseases, diseases of nutrition and somatic malformations in the same families, so far from complicating the problem, really contributes largely to its solution. This dissimilarity and discontinuity in the heredity is repeatedly emphasized by numerous illustrative examples. It is shown that morbid predisposition to general diseases may belong to the same general class of evolutionary defects or degeneracies, which, unless eliminated by fortunate crosses, will ultimately culminate in sterility and consequent extinction. Yet the dissolution of heredity, like normal evolution, has its laws. The variability of degenerescence is not hap-hazard, but conforms to certain well known types which are common to all degenerates, whatever may be the cause of the degeneracy —whether due to a cumulative morbid heredity, to old age, youthfulness, or great disparity of age of the parents, to permanent or even temporary lowering of their vitality, to drunkenness and other intoxications, to infections and in particular to syphilis. The view that

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[1]Fere, Ch. La Famille Névropathique, Théorie tératologique de l'hérédité et de la prédisposition morbides et de la dégénérescence, 334 pp., 25 figures. *Paris, F. Alcan*, 1894.

the human race, like the domestic animals, tends in degenerescence to revert to ancestral conditions is vigorously combated.

The concluding chapters discuss quite fully the stigmata of degeneracy, many of which are illustrated with half-tones taken from photographs. These stigmata are defined as characters, transmissible usually by dissimilar heredity, which deviate from the type of the race to which the individual belongs and which tend to eliminate the family exhibiting them from the race. They must be carefully distinguished from deformities resulting from pre-natal accidents, intra-uterine diseases, syphilis, etc., and also probably from those resulting from atavism. They may all be included under disturbances of the embryonic evolution, which may in general be characterized as the dissolution of heredity. It is to be remembered that these stigmata are characteristic of all kinds ef degeneracy in common, from whatever cause, and that therefore the attempt to establish a criminal type has been vain. Mal-nutrition, general or localized, is regarded as the common cause of most of the degeneracies; they may therefore be counteracted, either by appropriate crosses with vigorous stock or by any other means which will elevate the vitality of the family affected.

C. J. H.

Bissell's Manual of Hygiene.[1]

To the practical neurologist few subjects are of more direct interest than matters of personal and public hygiene. The intimate relation which exists between many neuroses and unsanitary conditions both within the body and in its environment, is too patent to require demonstration. The work before us has much to be commended. The style is simple and direct and the subjects chosen for discussion are for the most part such as are of the greatest practical importance to the public at large as well as to the physician. For instance, contagious and infectious diseases are treated in a practical non-technical manner, and among these tuberculosis is given an amount of space commensurate with its importance.

The work is prepared by the author to serve as a basis for a course of lectures to her own classes of undergraduates in a medical college. It is planned along pretty good lines and will doubtless serve this purpose very well; but much will depend on the course of lectures given, for the treatment in this manual of most of these sub-

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[1]BISSELL, MARY TAYLOR. A Manual of Hygiene. *New York, The Baker and Taylor Co.*, 1894.

jects will be found to be totally inadequate even for elementary instruction. The book cannot therefore be recommended as a general text-book, though it might serve as an introductory reading book. Its usefulness even here, however, is greatly diminished by the absence of sufficiently numerous references to the larger works and original memoirs.

The author writes truly: "The important role which micro-organisms play in nature, both beneficent and harmful, their direct relation to certain diseases, and their very wide distribution in the earth, make it essential that we should know the principal facts in the life history of these influential beings," yet the chapter on the biology of micro-organisms is one of the least satisfactory in the book. The introductory sentence states, "There are three general classes of microorganisms, known as bacteria. yeasts and moulds," and the remainder of the chapter is written in the same slip-shod fashion. It is to be regretted that fundamental biological principles are not brought into greater prominence throughout the work. The general instruction in many of our best medical schools seems to the reviewer to be faulty along this same line. The young physician is prone to regard the body as a machine whose parts when out of order require to be tinkered, rather than as an organism whose vital equilibrium is the all-important prerequisite to proper functioning.

The Comparative Morphology of the Brain.

The year just closing has brought forth many papers on the morphology of the lower brains from the standpoint of phylogenetic relationships. It is our purpose to notice here a few only of these papers.

An interesting discussion was opened by DR. BURCKHARDT in a paper which we have already noticed (p. xxii) and of which a reduced copy of the figure was given by Mr. Sorensen (p. 157, Fig. 3). Two months later he published another article on the Homologies of the Diencephalic Roof in Reptiles and Birds.[1] In studying these types (Lacerta and Corvus) in median section he was struck with their similarity to Petromyzon. In the diagram of Lacerta (also reproduced by Mr. Sorensen, p. 156, Fig. 2) we are struck by the great development of the "Zirbelpolster" and paraphysis. He concludes, "From these observations it follows that the parts of the lower brains exposed

[1]Die Homologien des Zwischenhirndaches bei Reptilien und Vögeln. *Anat. Anz.*, IX, 10, Feb., 1894.

by median section recur in the brain of the Sauropsida with certain modifications. Since these modifications consist chiefly in displacements of the vertical [dorsal] plate between the post-commissure and the recessus neuroporicus, and since the shortening of this region is accompanied by the elongation of the lamina terminalis, I think that I may be justified in concluding that these modifications may occur under the influence of the highly developed cerebrum, especially its hinder part, in the Sauropsida. The structural plan of the median section is in other respects the same as in the Ichthyopsida. The ependymous portions of the brain, which appear most constantly in median section, have the highest significance as primitive structures. They will attain for the comparative anatomy of the nervous system the same importance as cartilage for the comparative anatomy of the skull."

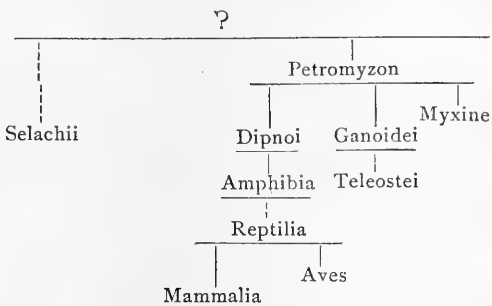
In a third communication[1] he attacks the fore-brain of fishes, that "most variable part of the fish brain." The difficulty experienced by observers hitherto has been to refer the diverse forms of fish brains to a type which may serve as a criterion. Such a type this author finds in Notidanus. Not only are all transitions in cerebral structure from the teleosts back to the ganoids present; but the cerebrum of ganoids also possesses the closest resemblance to that of the Notidanidæ, the Holocephali, and to Ceratodus as the most primitive of the Dipnoi. The criteria of judgement for the cerebrum of fishes center about the morphological properties of the lamina supraneuroporica (Kupffer's "præpinealis Zwischenhirn" and "Palluim des Parencephalon"), its limits and relations to the walls of the cerebrum, together with the characteristics of the adjacent cerebral walls and the extent to which they are thickened. The attempt is made to derive the selachian brain from that of Notidanus, but the author adds that the peculiar structures by which the mass of the cerebrum is increased in selachians are so totally different from those employed by higher animals that we may question whether their hemispheres may be compared with those of higher animals. Finally the conclusion is drawn that, using as morphological data the extent and properties of the lamina supraneuroporica, the thickening of the prosencephalic walls, the relations of the ventricles and olfactory lobes, it is quite possible to refer all these different forms to a common type. This type is characterized by having the whole cerebrum, whose walls are of uniform

[1]Zur vergleichenden Anatomie des Vorderhirns bei Fischen. *Anat. Anz.*, IX, 12, April, 1894.

thickness, terminated by a triangular dorsal lamina supraneuroporica whose apex lies in the recessus neuroporicus (Lobus olfactorius impar of Kupffer).

In the mean time STUDNICKA has published a paper on the Forebrian of the Craniota,[1] in which he challanges the current doctrine as established by Mihalkowicz, Rabl-Rückhard and others that the bilobed prosencephalon of the Amniota is derived from an unpaired condition, either in the ontogeny or the phylogeny. This author's studies on the development of Petromyzon have convinced him that in this type the hemispheres are paired *from the first.* If there is at any stage an unpaired condition of the hemispheres, this is secondary. They appear not as evaginations, but as thickenings of the walls of the the brain tube. So also in the phylogeny, Petromyzon is regarded as the primitive type, the unpaired condition of the selachian brain being very aberrant. In the teleosts the so-called pallium is a sort of tela choroidea of the tractus olfactorius, a secondary and purely special modification. The massive basal ganglia are therefore homologized directly with the hemispheres of Petromyzon. In the unpaired cerebrum of selachians either the lamina terminalis is enormously thickened or else the terma is supplanted entirely by the cerebrum.

The course of phylogenetic development is summarized as follows:



BURCKHARDT in a reply to this article[2] corrects some misstatements and criticises the author's methods of work A mere resemblance in cerebral structure is not sufficient basis upon which to draw phylogenetic conclusions.

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[1]STUDNICKA, F. K. Zur Lösung einiger Fragen aus der Morphologie des Vorderhirns der Cranioten. *Anat. Anz.*, IX, 10, Feb., 1894.

[2]Bemerkungen zu F.K. Studnicka's Mitteilung über das Fischgehirn. *Anat. Anz.*, IX, 15, May, 1894.

DR. RABL-RUECKHARD follows with a more extended reply to the same article,[1] in which he urges that Studnicka's position is not only very obscurely stated, but rests upon insufficient evidence, and that, moreover, he has not correctly stated Rabl-Rückhard's views in several particulars.

The whole question as to paired or unpaired cerebrum is vain so long as the rhinencephalon is left out of the account. Where the rhinencephalon is paired we may speak of a paired cerebrum. Now the selachian brain has a very evidently paired rhinencephalon. Moreover the development history of this brain shows that in old embryos the cerebrum also originates from paired anlags. Neither are we justified in speaking of the teleostean brain as unpaired. Rabl-Rückhard, then, goes further than Studnicka and insists that all vertebrates, *not excepting the selachians*, possess a paired cerebrum. They can all therefore be reduced to a common type the deviations from which consist wholly in alterations in the walls of the various segments. Thus the selachians differ from the teleosts chiefly in the massiveness of the roof of the cerebrum. Now, conceive the internal dualism of the teleostean brain to become evident externally by the appearance in a massive dorsal wall of the falx cerebri primitiva and we have practically the amphibian brain. Not only is it possible to derive the selachian brain directly from that of the amphibians, but the fissura hippocampi (Edinger) is already indicated in the prosencephalic roof of selachians.

In the fish brain Studnicka would make the pallium a tela. This, our author insists, would relegate it to the diencephalic roof; but this is impossible because it is on the wrong side of the velum. Rabl-Rückhard does not here consider the possibility of homologizing the pallium with the paraphysis, nor does Studnicka himself mention it in this paper, though he does so in a later communication.

The conclusion is drawn that the Cerebrum of all Craniota without exception is in its most cephalic portion always paired; but that this fact is no way weakens the author's views of the structure of the teleostean brain. He declines to attempt the construction of a phylogenetic tree, but gives instead a page of drawings of sagittal sections of the hemicerebrum entitled "Schema der phylogenetischen Entwickelung des Vorderhirns." In this plate the types figured are arranged

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[1] Das Vorderhirn der Cranioten. Eine Antwort an Herrn F. K. Studnicka. *Anat. Anz.*, IX, 17, June, 1894.

in the following order : Petromyzon, Acanthias, Menopoma, Salmo, Ganoid type, Cyprinoid type, Chelonia, Ophidia, Mammalia.

In a brief communication STUDNICKA answers Burckhardt's criticisms of his earlier paper.[1] He says that he has abundantly shown that there is a relationship between the brain-form of the Amphibia and the Cyclostomata; but by recognizing this similarity in his scheme, he by no means intended to imply that the Amphibia or the Dipnoi are necessarily directly descended from Petromyzon. It might be merely case of a convergence. And in particular, he claims that his method—comparative anatomy and embryology, supplemented by fine histology—is a safer guide than the usual comparative-anatomical methods.

Subsequently STUDNICKA replies to Rabl-Rückhard's criticisms also.[2] He agrees with him in regarding the selachian and teleostean brains as structurally paired, though the extensive development of the terma in the one case and the lack of the falx in the other have caused them to be commonly described as unpaired. He also agrees with Burckhardt in looking upon Notidanus as a type form, the more perfect knowledge of which as worked out by Burckhardt, has filled a gap in his own theory. In view of these later anatomical discoveries he would relate the selachians to Notidanus and consider the latter as a link between the Cyclostomata and the Dipnoi and probably also the Ganoidei.

As to the homologies of the cerebrum of fishes, he supports his position by the discovery of a callosum in Petromyzon in about the same position as figured by Mrs. Gage in Amia ;[3] i. e., lying much further dorsad in the axial lobes than the anterior commissure.

In fishes Rabl-Rückhard's "ventriculus communis" and his "ventriculus tertius" together correspond to the third ventricle of Amphibia and Ammiota. The names third ventricle and ventricle of the diencephalon are not synonymous. The "ventriculus communis" is the aula of amphibian brains. In this paper he expressly homologizes the "pallium" of fishes, as Mrs. Gage has done before him, with the paraphysis (auliplexus) which he calls the "most anterior end

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[1]Eine Antwort auf die Bemerkungen R. Burckhardt's zu meiner vorläufigen Mitteilung über das Vorderhirn der Cranioten. *Anat. Anz.*, **IX, 22,** July, 1894.

[2]Bemerkungen zu dem Aufsatze : "Das Vorderhirn der Cranioten" von Rabl-Rückhard. *Anat. Anz.*, X, 3-4, Oct. 1894.

[3]The Brain of Diemyctylus, Pl. VIII, Fig. 103, *Pcm.*

of the tela." He supports his conclusion also from the previous publications both of Mrs. Gage on Diemyctylus and Amia and of C. L. Herrick on the ganoids and teleosts.

In a short paper before the Anatomische Gesellschaft[1] the same author continues the discussion of the significance of the pallium, especially in Petromyzon. He repeats the statement made in his first paper that the hemispheres here correspond only to the hindermost part of the hemispheres of higher animals, taking Edinger's ground that it is exclusively an olfactory centre. In support of his belief that the pallium is a "tela" or paraphysis, he figures a section of the Petromyzon brain, showing between the hemispheres and the pallium a massive part in the proper position for the fornix.

In a final paper[2] BURCKHARDT has brought together the main points of his earlier communications, together with some additional matter. The paper is in effect a very practical plea for the proper recognition of the morphological importance of the membranous portions of the encephalic walls. Following His, with some modifications, he divides the brain into the following longitudinal zones:

1. The base-plate (*Bodenplatte*), the ventral median line. This long remains membranous.

2. The ground-plate (*Grundplatte*), the zone from which the motor roots spring.

3. The alar plate (*Fluegelplatte*), the zone into which the sensory roots enter.

4. The intercalary plate (*Schaltplatte*).

5. The lateral plate (*Seitenplatte*).

6. The vertical plate (*Scheitelplatte*).

Numbers 1 and 6 are the median zones. They are more constant both in the phylogenetic and the ontogenetic series than the lateral zones. The median zones are normally membranous throughout life. If they become massive at any point (cerebellum, optic lobes, etc.) it is only through the influence of the lateral zones. That, however, the median zones have not utterly lost the power to differentiate into ganglion and neuroglia cells is shown by the epiphysis and its accessories (parietal eye). Probably the optic vesicles have evaginated from the base-plate just as the epiphysis has from the vertical

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[1]Zur Geschichte des "Cortex cerebri." *Verh. d. Anat. Ges., 8 Versam., Strassburg*, May, 1894, pp. 193-198.

[2]Der Bauplan des Wirbelthiergehirns. *Morphologischen Arbeiten, herausg. von Dr. G. Schwalbe, Jena*, IV, 2, pp. 131-150.

plate. The question is open how far the embryonic character of the ependyma is primitive and how far reductive. Goronowitsch argues for the degenerative nature of the pallium of fishes. This is debatable. Burckhardt considers it more probable that the brain of ganoids has given rise to that of teleosts by the lateral extension of the vertical plate, crowding the lateral zones to one side just as has been done in the roof of the fourth ventricle. Since histologically the median zones are the most primitive, we should expect that they would show also the smallest amount of morphological deviation in the various types. Such in fact is found to be the case.

Now follows a detailed description of the median zones in the different types of vertebrates, which could not be well abstracted without a reproduction of the plate which accompanies it. In this plate are represented the median sections of ten typical vertebrates from Amphioxus to man, so drawn by means of an ingenious color scheme that the homologous segments of the median zones appeal to the eye at once. The result is very impressive. The amount of variation is found to be surprisingly small. This plate will be useful to teachers for the purpose of demonstration to classes in comparative anatomy.

The causes which produce modification in the structural plan are briefly discussed and also the phylogenetic relationships. The brain of Notidanus is regarded as a primitive type. As to the lines of differentiation, the following points are suggestive:—The more primiitive the brain, the more uniform the thickness of the lateral zones, the less they influence the median zones and the less the brain axis is deformed. Increase of mass is of less importance than diversity of form. This specialization will take different paths. The teleosts represent a culmination ; so do the birds, mammals, and among the latter the microsmic mammals. In the median zones resides the conservative element; in the lateral zones, the progressive element. The one gives us the structural plan ; the other its modifications.

Though the papers above noted are written from different standpoints and show great diversity as to both methods and conclusions, yet the careful reader can hardly fail to be struck by the fact that, after all, the agreements are of greater importance than the differences Much permanent gain will certainly result from so careful a sifting of the facts by these eminently careful investigators.

C. J. H.

The Application of Methyl Blue to Mucous Membranes.[1]

Portions of the tissue to be studied, excised from an animal just killed, were placed in a 1 to 2 per cent. solution of methyl blue. The color penetrated much more rapidly, especially with cold blooded animals, if warmed to 30 deg. C. A slight addition of ammonium carbonate to the solution increased the sharpness of the effect. The color was fixed in concentrated ammonium picrate, remaining in the solution for several days. The preparations were then immersed in a mixture of glycerine and distilled water in which they may be left for several months without injury. Free, very fine termini were found uniformly distributed over the mucous membrane of the bladder. The mucous membrane of the vagina is more richly supplied with nerves than that of the uterus. Nerve termini were traced (1) in the mucosa, (2) in the muscular layer, which is quite as richly supplied as the preceding, (3) intra-epithelial nerve termini (?), (4) vascular nerves about the arteries, veins and capillaries. The termini are usually free without knobs. Strict anastomoses were not conclusively demonstrated.

The Crossing of the Respiratory Paths in the Cord.[2]

Seven experiments on dogs and rabbits operated upon under anaesthetics afford the most convincing proof of the following conclusions:

(1) The respiratory paths ascend in the lateral columns of the cervical cord; (2) the stimuli from the bulbar centres can excite (unless dyspnœa persists) the phrenic centre of the other side; (3) this decussation occurs at the level of the phrenic centre; (4) such a decussation does not occur in the cord between the phrenic centre and the calamus scriptorius.

To these anatomical discoveries the author appends the following hypothetical considerations: (1) The respiratory excitation descends in the lateral columns and ends in numerous ramifications at the levil of the phrenic nidulus of the same side. (2) The dendrids of all of the phrenic cells may be divided into two groups: one group containing many dendrids which lie in contact with the terminal ramifications of the descending lateral respiratory fibres; the other, containing rela-

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[1]KALISCHER, O. Ueber die Nerven der Harnblase, des Uterus und der Vagina. *Math. u. naturw. Mitth. Akad. Wiss. zu Berlin*, H, 7, July, 1894.

[2]PORTER, W. T. Ueber die Kreuzung der herabsteigenden Athmungserregung im Niveau der Phrenicuscentren. *Cent. f. Physiol.*, VIII, 7, 1894.

tively few dendrids, crosses in the protoplasmic commissure to the other side of the cord there to come into relations with the terminal ramifications of the descending respiratory fibres of this side. The terminal ramifications of the descending respiratory fibres of each side thus come into contact with dendrids of different origins; first with many dendrids of the motor phrenic cells of their own side and second with relatively fewer dendrids from the motor phrenic centres of the opposite side. (3) The descending respiratory excitations are chiefly discharged in the motor phrenic cells of the same side because the dendrids of this side are more numerous and therefore present less resistance than the fewer dendrids which have crossed over from the motor phrenic cells of the other side. (4) The section of one phrenic nerve interrupts the customary respiratory path of the same side and the stimulus crosses to the opposite side by means of the decussating dendrids and thus excites the other phrenic nerve.

Intrinsic Nerves by the Golgi Method.

The second Report in Neurology from the Johns Hopkins Hospital (Vol. IV, Nos. 4-5, of the Reports) is a very important document for the working neurologist. The papers are all prepared by Dr. Berkley and, with the exception of the first, comprise practically one continuous investigation.

I. Dementia Paralytica in the Negro. Five cases are presented, with a plate of histological preparations.

II. Studies in the Histology of the Liver. The intrinsic nerves of the liver, in the main, present little variation in their course or terminations from the nerve elements of other, already studied glands. The newest, as well as one of the most important additions to our histological knowledge that has been furnished by this study, has been the discovery that the vessels of the portal circulation are furnished with a rich supply of nerve fibres, a circumstance that, however, might have been readily forseen from the physiological experiments of Pal and Mall upon the portal circulation. Next in importance in our study is the influence of the nerves upon the gall canals, it being demonstrated that they probably supply the unstriped muscle of the outer layer of the ducts, and also with great probability enter into the cement substance between the columnar cells lining the canal. Thirdly, that the fibres coming from the walls of the portal veins and hepatic arteries, and passing between the liver cells, are not true nerve fibres as has been supposed by Nesterowsky and others, but belong to the reticuated tissue system, and that the true nerve endings of the liver do not differ in any material way from those of other organs. Lastly, that neural enlargements, that have never been found among the doubtful fibres, do occur, though the silver stain does not show them with frequency. Medullated fibres have a very doubtful existence within the proper limits of the hepatic organ, the osmium-copper-hematoxylin stain having failed completely to bring them into view, while the silver method gives no indication that they are present.

III. With this study on The Intrinsic Pulmonary Nerves in Mammalia our readers are already familiar (Vol. III, pp. 107-111).

IV. The Intrinsic Nerve Supply of the Cardiac Ventricles in Certain Vertebrates.

1. The interspaces of the muscular bundles of the heart of mammalians, batrachians, Amiurus, chelonians, and aves, are thickly filled, from the apex of the ventricles to the auriculo-ventricular groove, by a dense network of coarser and finer anastomosing nerve fibres, which touch at some point each bundle, but end-terminations are not always to be found in contact with every muscular cell.

2. The terminal apparatus of the varicose networks acting upon the muscular fibres, is most frequently at the end of a short transverse ramus, arising in the course of a longitudinal fibre, and has always the aspect of a simple bulb of varying size.

3. Neural enlargements of considerable diameter are found developed in all the species of animals examined, upon the fibres of the inter-muscular network. These neural swellings are probably nucleated. Transition forms from the smallest varicosity on the thinnest nerve fibre, to enlargements .01 mm. or longer, may be found in all well stained sections.

4. Nerve cells of the sympathetic system have a probable existence within the ventricular walls, and are in form spindle, pyramidal, or stomach-shaped. The axis-cylinders from these cells (mouse), are directly connected with the fibres of the varicose plexuses. A spray of terminal fibres upon the isolated cells is probable.

5. More complex end-apparatus than the simple bulb of the varicose networks has only been seen within the ventricles of the highest orders of vertebrates examined, the dog, mouse, and albino rat, but from the rarity of the observations their constant presence is by no means positive, but it is probable. True end-plates have not been found.

6. All the eight species of animals examined presented similar intrinsic ventricular, nervous structures, muscular networks with simple bulbar end-apparatus, neural thickenings, and cell-like bodies re-

sembling small ganglionic nerve cells, though of different forms, but complex endings of the fibres were seen only in three of the varieties.

Five plates illustrate this section.

V. The Intrinsic Nerves of the Sub-maxillary Gland of Mus musculus. This study in the main corroborates the earlier observations of Cajal and Retzius. This gland proves to be an unusually favorable subject for the demonstration of intrinsic nerves by the Golgi method. The terminal endings of the acinus plexus are apparently situated in a two-fold position in respect to the cells of the duct. In cross and oblique sections of the acini, especially in the latter, the nerve fibres may distinctly be observed to pass through the membrana propria of the tube, and the bulbar ending of the fibre is found to lie upon the extreme outer edge of the secretory epithelial cell, most commonly about the central region of the cell. This constitutes the common, or infra-cellular type of ending. The second form—the inter-epithelial type of ending—is seen with less certainty and frequency, the nerve filament passing through the limiting membrane of the tube, apparently entering the cement substance between two of the epithelial cells, and there ending with a knob-like termination.

In a considerable number of sections, generally in the neighborhood of the hilum of the gland, and located near a secretory duct and an artery, were found nests of large unstained sympathetic cells. These cells were of an irregularly rounded, or globose shape, with very clear protoplasm and nucleus, the processes in immediate conjunction with the cellular body entirely untinged by the chrome-silver. Each cell-nest held from twenty to thirty ganglion cells, with but a narrow interval between each individual body, in which were numerous single nerve fibres. These fibres ended in arborizations upon the cellular elements, and could be traced from their terminations into the networks surrounding the larger arteries and salivary ducts, where they were eventually lost. Portions of the finer dendrids of the sympathetic cells were also impregnated, and their terminal portions formed curved knotty endings around the rounded bodies of the nerve cells, enwrapping them with coarse, irregular branchlets.

VI. The Intrinsic Nerves of the Thyroid Gland of the Dog. The author's impregnations give a meshwork of fibres situated almost immediately upon the basal surfaces of the epithelial cells of the follicles, from which the largest proportion of the nerve endings are derived. The end-apparatus offers some slight difference in form from that peculiar to the majority of glandular organs. In the place of the familiar globular or flattened globular endings, the majority of the terminations are now cone-shaped, though the rounded apparatus is by no means excluded. Ganglion cells were not found, but in their place appear quite numerous neural nodes situated among the fibres of the peri-follicular meshworks, adjacent to them being situated the only thickened nerves of the organ.

VII. The Nerve Elements of the Pituitary Gland. In the glandular portion of the hypophysis no nerve cells are to be found and all nerves belonging to it appear to be derived from branches of the carotid sympathetic plexus.

In the infundibular lobe it is only here and there through the anterior two-thirds that the silver stain affords examples of the variety of nerve cells of the body. The only group of nerve cells is at the extreme base. All the ganglionic elements belong to the multipolar type. The most beautiful dendridic forms are presented in astonishing variety. The axis-cylinder extensions of all the cells in the infeferior portion of the lobe turn upwards, as do most of the others observed. It is doubtful whether any of these fibres pass beyond the limit of the lobe into the infundibulum, these sections giving no evidence of such an arrangement, while on the other hand, the nerve fibres accompanying the larger arteries are sometimes distinctly seen coming from the infundibular tract into the body of the posterior lobe of the gland and ramifying through it. It is probable, too, that some portion of the threads in the posterior secretory portion of the lobe are also derived from these vascular filaments, but connection between the fibres of the vascular supply and the nerve cells of the organ has never been observed.

In the central regions of the lobe certain rounded or oval bodies are observed which in the chrome-silver preparations have a likeness to closed follicles, but no visible structure. Around these bodies the axis-cylinder processes coil with an intricate arrangement, the main fibres in their upward course diverging around them, while from the same fibres arise others that after passing to the oval bodies develop upon themselves very extraordinary figures. These fibres twist and coil upon themselves, develop irregular thickenings, the most common being an irregular comb-like figure with knobs set on the ends of the blades. There is also a tufted form, and sometimes only a development of intricate knobs is observed extending from a blackened mass having a nerve fibre passing into it. These structures resemble the endings of the mitral cells of the olfactory bulbs, the so-called olfactory glomeruli, and it is more plausible to refer them to some organ of special sense, existing fully developed in the lower forms of animal life than to endings upon sensory epithelium.

The silver method shows that the pituitary gland has retained in one of the higher orders of vertebrates (adult dogs) its double role of secretory and nervous function intact; the former perhaps modified, the latter, the original special sense organ, probably simply lying quiescent, not atrophied, and only changed so far as to admit of a slightly different arrangement of its constituent elements.

The Brain of Birds.[1]

The earlier parts of this work previously abstracted (Vol. III, pp. cxii-cxvii) dealt with the transition between the cord and the medulla and the internal origins of the nerves from the medulla. The Hypoglossus (I) and the the Vagus groups (II) were discussed.

III. Acusticus Group. (*a*). Nervus cochlearis. This nerve springs from a ganglion which contains three structurally distinct elements which probably not only constituted originally a single ganglion but one which was gradually imbedded in the substance of the medulla from without. Not all of the emerging fibres spring from cells of this cluster and on the other hand the cells of the most ectal division contribute fibres to the corpus restiforme as well as the cochlear root. Those fibres of the cochlearis which pass further cephalad first enter the raphe in which they pass forward and occasionally cross. These are assumed to be the central tract of the acusticus, while other smaller fibres at first associated with them, which cross immediately in the raphe, pass to the formatio reticularis and thence to the cerebellar peduncle. The cochlearis also probably gives a tract to the cerebellar peduncle of the same side. The passerine birds have the ganglia of origin of the cochlearis more extensively and more intricately developed than any others except the owl, in which the ganglia are larger.

(*b*). Nervus vestibularis. The greater part of these fibres pass directly to the raphe. It is interesting to note that, like motor tracts, they become medullated very early in new born birds. They originate in a root-ganglion external to the medulla but closely appressed to it. After crossing in the raphe they seem to enter the dorso-median fasciculus, an appearance which was confirmed by Marchi's method of

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[1]Brandis, F. Untersuchungen über das Gehirn der Vögel. II Theil: Ursprung der Nerven der Medulla oblongata (Continued); Das Kleinhirn. *Arch. f. mik. Anat.*, XLIII, 1 and 4, 1894.

degeneration. This nerve, like the preceding, seems to have connections with the cerebellum. The N. vestibularis is more highly developed in birds of good powers of flight than in others.

(*c*). Nervus facialis. These fibres are distinguished from those of the two preceeding nerves not only by their distribution, but by their greater size and more intense color. They pass to their nidulus after making the genu, as in all other vertebrates. A few fibres seem, however, to pass directly to the raphe with those of the N. cochlearis.

The Cerebellum. In birds the three peduncles are not distinct and by reason of the absence of the pons the fibres of the middle peduncle are not represented. The details of the cerebellar connections were fully investigated both by the fibre-sheath stain of Weigert and the experimental method of Marchi. The anterior peduncle is represented by fibres which arise for the most part from the central niduli, though some may come from the cerebellar cortex also. Most of the numerous elements found in the posterior peduncle of mammals are also represented there in birds. Thus we find here the lateral cerebellar tracts, numerous fibres from the dorsal columns, many from the formatio reticularis most of which probably originate on the opposite side, some from the cells surrounding the formatio reticularis (Bechterew's nucleus of the lateral column?), and a probable tract from the olives.

The Sense Organs of Lumbricus.

Two new papers on this subject appear simultaneously each confirming Smirnow's discovery of free nerve termini in the skin (cf. this Journal, IV, p. cxxxvi). Miss Langdon[1] describes not only such termini, but multicellular sense organs everywhere scattered over the skin in accordance with a definate pattern. These organs each contain 30 or more cells so closely resembling the isolated ganglion cells of Lenhossék that the author is constrained to believe that they are identical with them.

Dr. Retzius[2] illustrates several varieties of such free termini as Smirnow described.

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[1]LANGDON, FANNY E. The Sense Organs of Lumbricus agricola Hoffm. Preliminary Notice. *Anat. Anz.*, X, 3-4, Oct., 1894.

[2]Die Smirnow'schen freien Nervenendigungen im Epithel des Regenwurms. 7 figures. *Anat. Anz.*, X, 3-4, Oct., 1894.

The Morphological and Histological Development of the Cerebellum of Teleosts.[1]

This important paper presents the details of an investigation extending through several years upon the salmon and trout. The cerebellum of teleosts develops from a bilaterally symmetrical anlag which at first is produced by a sharp transverse fold at the lateral aspects of the nerve-tube between the vesicles of the mesencephalon and medulla. The subsequent growth is from below upwards toward the median line in the caudal limb of this fold. Two thickened columns are thus formed which constitute the anlag of the future cerebellum, while a secondary median fold arising later develops into the valvula cerebelli. The ventricular space between the two lateral columns expands above into a "cavum cerebelli primitivum," while below it is quite obliterated by the subsequent thickening of the pillars. A central canal in the sense of earlier authors does not exist in most fishes.

In the discussion of the histological development the author brings forward many points of interest to the morphologist. The teachings of His regarding the relation between the neuroblasts and spongioblasts are controverted. It is claimed that a fundamental distinction between the germinal cells and the epithelial cells (in the sense of His[2]) does not exist. The elements called germinal cells by His are nothing but young or segmenting epithelial cells of the primitive ectodermal anlag. From a certain point of time onward, these germinal cells give rise no longer to epithelial cells, but to a generation of indifferent cells, which wander peripherally to take up a position between the epithelial cells and the membrana limitans externa (mantel zone). From these indifferent cells there arise later both nerve cells and glia cells. With the increasing differentiation of the cerebellum a certain number of indifferent cells do not undergo metamorphosis. They can multiply by karyokinesis and thus furnish the material required for the nerve cells and glia cells of the other structures. Probably the capacity for subsequent regeneration in the central nervous system is to be referred to the persistence of some of these indifferent cells. The whole neuroglia frame-work of the cerebellum is ontogenetically to be referred to the indifferent cells and that part of the primitive epithelial cells of the medullary tube which persists as epen-

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[1]SCHAPER, A. Die Morphologische und Histologische Entwicklung des Kleinhirns der Teleostier. *Morpholog. Jahrbuch.*, XXI, 4, 1894; also a Preliminary Contribution in *Anat. Anz.*, IX, 16, June, 1894.

[2]Cf. the review in this Journal, Vol. I, pp. i-iv.

dyma. It is thus wholly ectodermal. The few elements of connective tissue nature which migrate into the cerebellum with the blood vessels (and in this way alone) are found only in the adventitia of the vessels.

The transitory superficial granular zone of the cerebellum, which has so long puzzled morphologists, has been fully worked out. Its cells arise wherever the typical cerebellar substance passes over into a simple epithelial layer (transition from the cerebellum into the velum medullare posterius etc.) From these places they wander over the entire cerebellar superfices. They are indifferent cells and give rise to both nerve cells and glia cells. The later disappearance of the superficial granular zone arises from the centrally directed migration of its elements. It follows, then, from these researches that we have in the cerebellum centres of proliferation from which the histological elements migrate, very much as has been already described for the cerebrum by C. L. Herrick and others.

C. J. H.

Nerve Endings in the Human Eye Lid.[1]

Professor Dogiel has applied to the border of the eye-lid and the conjunctiva palpebrarum the methyl blue coloration which has already yielded so good results in his hands. He finds terminal organs (Endkolben, W. Krause) similar to those already described in the dermis, in the conjunctiva bulbi and the skin of the external genitals. These terminal corpuscles receive medullated fibres only which arise from a broad-meshed web of medullated and non-medullated fibres lying in the deeper layers. The nerves supplying these corpuscles sometimes anastomose, as in the author's previous cases. Many of the medullated fibres do not enter these corpuscles, but end in a complex sub-epithelial meshwork from which arise free inter-epithelial termini.

The non-medullated fibres supply the Meibomian glands and the blood vessels.

The Ciliary Body and Iris of Birds.[2]

Vaso-motor, motor and sensory nerves all enter the ciliary body from the circular nerve complex. Tendril-like intra-muscular sensory

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[1]DOGIEL, A. S. Die Nervenendigungen im Lidrande und in der Conjunctiva palpebr. des Menschen. *Arch. Mikr. Anat.* XLIV, 1, Sept., 1894.

[2]MELKICH. Zur Kenntnis des Ciliarkörpers und der Iris bei Vögeln. *Anat. Anz.*, X, 1, Sept., 1894.

termini are figured from the ciliary body. Somewhat similar termini are figured in the iris, together with an intricately meshed terminal plexus superficially.

The previous observation that the circular and radial muscular fibres freely anastomose is verified and the interesting fact is added that the same motor fibre often divides so as to supply one end organ to a radial and another to a circular fibre. The musculature of the iris, then, like that of the ciliary body, both as regards its structure and its innervation, must be regarded as a single, rather than a double mechanism.

The Significance of the Optic Purple in Vision.[1]

Some of the author's more important conclusions are given in the seven theses below. For the detailed observations and experiments from which these conclusions are derived we must refer the reader to the original paper.

1. In the fovea centralis (and all cones) no optic purple occurs.

2. The uncolored sensation (gray) generally called forth at the threshold of the stimulus (with the exception of the red) is occasioned by a feeble decomposition of the optic purple.

3. By stronger decomposition of the optic purple, up to the point where the optic yellow is first formed, the sensation of blue is called forth.

4. The two still-unknown optic substances for the two other fundamental sensations red and green are (like the optic yellow) more difficult of decomposition than the optic purple.

It follows from 1 and 3 that the fovea is blue-blind; trichromatic persons have here a dichromatic color system and dichromatic persons a monochromatic color system. This area has in the authors' right eye an apparent diameter of 55 to 70 minutes of arc, which is thus larger than the angle subtended by the moon. Viewing the moon through blue glass the author succeeded after long practice in holding the gaze steady enough to cause the disc to disappear entirely when fixed in the fovea. The sensation is not that of looking into empty space formerly occupied by the moon, but as if the gaze were fixed close beside the latter. A sort of vicarious point of fixation seems to have been established.

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[1]KOENIG, A. Ueber den menschlichen Sehpurpur und seine Bedeutung für das Sehen. *Math. und naturw. Mitth. Sitzb. Akad. der Wiss. zu Berlin*, Heft 6, 1894.

5. In total color blindness the optic purple is the only light-perceiving substance. The optic yellow arising from it is here, however, not capable of further decomposition.

6. The hitherto observed exceptions to Newton's law of color mixture and Purkinje's phenomena can be explained by the fact that with increasing intensity of the light the spectral subdivision alters its stimulus value for the sensation called forth by the decomposition of the optic purple and the optic yellow.

7. The physiological process associated with the sensation of white is not an intensifying of that associated with gray (the threshold of the stimulus.)

Recurrent Images following Visual impressions.[1]

This paper details some carefully planned and very instructive experiments bearing on the oscillatory character of visual impressions. We can give only the author's summary. Those interested in the physiology of vision or of nerve transmission should consult the original paper.

It appears that when the retina is exposed to the action of light for a limited time, the complete order of visual phenomena is as follows:

(1). Immediately upon the impact of light there is experienced a sensation of luminosity, the intensity of which increases for about one-sixtieth of a second; more rapidly towards the end of that period than at first.

(2). Then ensues a sudden reaction, lasting for about one-sixtieth of a second, in virtue of which the retina becomes partially insensible to renewed or continued luminous impressions. These two effects may be repeated in a diminished degree, as often as three or four times.

(3). The stage of fluctuation is succeeded by a sensation of steady luminosity, the intensity of which is, however, considerably below the mean of that experienced during the first one-sixtieth of a second.

(4). After the external light has been shut off, a sensation of diminishing luminosity continues for a short time, and is succeeded by a brief interval of darkness.

(5). Then follows a sudden and clearly-defined sensation of what may be called abnormal darkness—darker than common darkness—

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[1]BIDWELL, SHELFORD. On the Recurrent Images following Visual Impressions. *Proc. Roy. Soc.*, LVI, 337, Sept., 1894.

which lasts about one-sixtieth of a second and is followed by another interval of ordinary darkness.

(6). Finally, in about a fifth of a second after the extinction of the external light, there occurs another transient impression of luminosity, generally violet-colored, after which the uniformity of the darkness remains undisturbed.

The Tactile Areas of the Cerebral Cortex.[1]

The third paper in Professor Munk's series on the "Fühlsphaeren" has appeared in the July fascicle of the Transactions of the Berlin Academy. In the first of these papers the author adduces experimental evidence in substantiation of the opinion, somewhat tentatively expressed in an earlier work,[2] that the tactile sensations of the various regions of the body are localized in cortical areas coincident with the motor areas already established for the same regions. He thus reconciles the contradictory experiments of those who find that there results from the destruction of these areas the loss of tactile sensation only without motor disturbance in the parts affected (Schiff) and those who find only motor paralysis without permanent sensory disturbances (Ferrier). Besides the account of the author's own experiments, there is an ex tensive controversial discussion of the results of Goltz, Ferrier and others in the same field, and especially with reference to the common sensations and reflexes. It is shown that after the total extirpation of the cortical area for an extremity there is an influence upon the reflex centre of the cord pertaining to this extremity. The reflex excitability is at first greatly diminished, but soon again increases to a maximum which remains constant thereafter. This diminution is not due to any inhibitory effect of the operation, as taught by Goltz, but merely to the interruption of the paths of conduction between the cortical and the spinal centres, thus making necessary a re-arrangement of the elements within the latter. These phenomena are called "alterations of isolation."

The second and third papers deal with the motor disturbances

[1]Munk, H. Ueber die Fühlsphaeren der Grosshirnrinde. *Sitz. der k. preuss. Akad. der wissenchaften zu Berlin:*

1st. Mittheilung, July, 1892.
2d. Mittheilung, Oct., 1893.
3d. Mittheilung, July, 1894.

[2]Ueber die Functionen der Grosshirnrinde. *Zweite Auflage, Berlin.* 1890.

following extirpation of these areas in monkeys and dogs. After the destruction of the centres for the various regions of the body, the proper voluntary motions of these parts are forever impossible. There remain only certain "common motions" arising from the common reflexes and these latter experience alterations of isolation like those of the reflex excitability. Certain so-called principal motions, such as walking, etc., are shown to be in monkeys independent of any individual parts of the cortex, and even of the cortex as a whole. This, it will be observed, accords with the results of Goltz, though the fact is very differently interpreted by the two operators. Munk, however, insists that even these motions are, to a certain extent at least, regulated and refined by the cortical areas.

The third paper deals largely with the muscular paralysis and atrophy which follow extirpation of the cortical areas. This paralysis or atrophy is not a primary effect of the destruction of the centres but follows only secondarily from disuse.

The Psychic Faculties of Decerebrated Dogs.

The interest excited by Professor Goltz's remarkable operations does not abate and the curious controversy with Professor Munk continues to quicken that interest. We have already presented (Vol. III, p. xxvii) in a brief notice a few of the points of interest in Professor Goltz's observations, and later (June, 1893, pp. 69–77) Dr. Edinger's report upon the brain of the most interesting of these dogs.

Professor Munk in an address before the Physiological Society of Berlin last February[1] went over the ground quite thoroughly and discussed the conclusions reached by Professor Goltz in detail. It is urged that to claim that the removal of the cortex simply diminishes, but does not destroy consciousness really argues for the presence of sensations, affections and will in the decerebrated dog and that this is as absurd as to insist upon such faculties in the animal whose whole encephalon had been severed from the cord, by reason of the apparently purposive movements made by the torso when irritated.

Taking up, now, the separate senses, Professor Goltz insists that his decerebrated dogs were not blind, as they not only avoided obstacles but would blink at a strong light. Since no other vertebrates exhibit this latter phenomenon, Professor Munk questions the validity of the observation. But granting the fact, the reflex may be from

[1]Ueber den Hund ohne Grosshirn. *Archiv f. Anat. und Physiol.*, Physiol. Ab., 1894, 3-4.

the trigeminus (via ciliary nerves) to the facial—not from the opticus —and hence we cannot speak of vision in the matter. But again granting that optic fibres transmit the stimulus, reflex connections effected in the pulvinar, corpus geniculatum externum, etc., by no means imply that a luminous sensation has been called forth. In fact we have independent evidence that a sensation is not evoked by such a reflex. Professor Munk insists that the decerebrated dogs were blind—totally blind.

The hearing of these dogs is next considered and it is urged that their actions do not evidence that they heard the fog horns, etc.; but that these harsh sounds produced mere reflexes arising from a sense of unintelligent discomfort. Such sounds are capable of evoking common reflexes, even though they were not heard and though they called forth neither pleasure nor pain. The motions of the dogs were not those of attention, but those of common reflexes. Moreover, they obey the laws of the latter, not those of the former. The conclusion, then, is that what Professor Goltz saw as a result of the noises has nothing whatever to do with hearing and the decerebrated dog was quite deaf. The whining, barking, howling, etc. observed, do not contradict Munk's observation that dogs deprived of the "Hörsphæren" are both deaf and dumb, for these sounds were made only upon the immediate application of a strong stimulus; never from psychic stimuli like presence of food or desire for mates. Neither the phenomena observed by Goltz nor Munk are due to a general weakening of mental power, but both to an actual psychic deafness.

The "tactile sense" of Goltz, too, is merely an excitation of the common feelings which produces common reflexes. It must be remembered that sensations of contact or pressure are indissolubly linked to local signs. These produce in the aggregate common feelings which in turn, are associated with common reflexes, each of which arises only upon the occasion of mechanical irritation of a particular cuticular area. Now in Professor Goltz' dogs the most characteristic feature of tactile sensations—localization—is lacking by his own confession. The tactile hyperæsthesia observed in these dogs is quite incomprehensible on his supposition of a general lowering of the psychic faculties, but not an abolition of them ; but from Professor Munk's standpoint it would be quite natural to suppose that the common feelings, would be intensified by the loss of tactile sensations. This is in accord with the known facts of hyperexcitability of lower centres after their separation from the inhibitory higher centres.

Such is Professor Munk's commentary upon Professor Goltz' observations. It is to be regretted that two investigators, both so justly renowned in the history of cerebral localization, should find it necessary to dwell upon the points of disparity in their respective experiments, rather than to seek for agreements in observation and harmony of interpretation. To others these observations have seemed not so incompatible as might at first appear. The facts of cerebral localization, as clinically and experimentally demonstrated, in themselves and aside from any philosophical theories based upon them, contribute no evidence whatever to a solution of the problem of the seat of consciousness. That the proper functioning of a given locus in the cortex is essential to the execution of a given motion or the reception of a given sensation by no means necessarily implies that the consciousness of the act is located there. This latter is an entirely independent problem which must be separately investigated. It is not, then, the facts of cerebral localization which can be called into question, but the interpretation of these facts, and it is not improbable that the true interpretation lies somewhere between the extremes represented by these two investigators. The thorough discussion which has been provoked cannot fail to leave the subject in much clearer light than it was before, even though neither of the principal participants may find his views accepted in their entirety.

The Temperature Sense.[1]

Some 5000 tests were made on 30 young men. The various regions of the body were tested for relative sensibility to heat and cold by the use of test tubes containing water at temperatures from 0° C. up to 70° C. The parts of the body given in the order of their sensibility are, (1) abdomen, sacral and lumbar regions of the spine, with the intervening space on each side of the body; (2) inside of thigh, chest, cervical spine, and upper dorsal spine; (3) inside of arm, outside of thigh, lower dorsal spine, and the soles of the feet; (4) Front of neck, inside of forearm, palm of hand, inside of leg, and top of foot; (5) Outside of forearm, outside of leg, and forehead.

Changes of temperature between 50° C. and 60° C. produce sensations of cold or of heat in all parts of the body with little or no pain. Temperatures beyond these limits cause pain in addition to sensations of cold or heat. These limits approach each other as the size of the stimulated area increases. The surface of the body is

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[1] RILEY, W. H. A Study of the Temperature Sense, *Jour. Nerv. and Ment. Disease*, XXI, 9, Sept., 1894.

more sensitive to temperatures below its own surface temperature than to temperatures above it. The skin is most sensitive to changes of temperature near its own zero point.

In five subjects hot spots and cold spots were mapped out in selected areas from all of the bodily regions. The parts of the body most sensitive to cold do not contain a greater number of cold spots than other parts. Again, contrary to Goldscheider's claims, the parts most sensitive to heat frequently had no more hot spots than other parts. It was proven that hot spots when stimulated with cold gave a sensation of cold; and the cold spots when stimulated with heat gave a sensation of heat. There are therefore not two separate sets of end-organs for heat and cold. This accords with Dessoir and not with Blix and Goldscheider.

The reaction time to heat and cold was studied in ten subjects. This time varies with the temperature, with the part of the body tested, with the conductivity of the skin to heat, and with the conductivity to heat of the instrument used in making contact with the skin. Whatever increase in the reaction time to heat or to cold there may be over the reaction time to touch, is due mainly, if not entirely, to the time occupied in raising the temperature of the skin in one instance, and lowering it in the other, to a point sufficiently far from the normal to produce a stimulation.

Play in the Lower Animals.

Dr. Jas. Weir, Jr., contributes some interesting observations on the Habit of Amusement in the Lower Animals to the October number of *The American Naturalist.* He writes, "I have seen, in actinophorous rhizopods, certain actions, unconnected with sexual desire or the gratification of appetite, which lead me to believe that these minute microscopic organisms have their pastimes and moments of simple amusement. On several occasions while observing these creatures, I have seen them chasing one another around and around in their minature sea. They seemed to be engaged in a game of tag. This actinophrys is not very agile, but when excited by its play, it seems to be an entirely different creature, so lively does it become. These actions were not those of strife, for first one and then another would act the pursuer and the pursued. There were generally four or five actinophryans in the game. One of the rotifers frequently act as if engaged in play. On several occasions I have observed them perform a kind of dance, a *pas seul,* for each rotifer would be alone by itself. Their motions were up and down as if exercising with an invisible skipping-rope. They would keep up this play for several minutes and then resume feeding or quietly remain at rest. This rotifer goes through another performance which I also believe to be simply a pastime. Its tail is armed with a double hook or forceps. It attaches itself to a piece of alga or other substance by this forceps, and then moves its body up and down in the water several minutes at a time." "Swarms of Diptera may be seen on any bright day dancing in the sunlight. Naturalists have therefore considered this swarming to be a mating of the two sexes. This is not the case, however, in many instances. On numerous occasions, and at different seasons of the year, I have captured dozens of these insects in my net and have examined them microscopically. I found them all to be unimpregnated females; I have never yet discovered a male among them. In some of the Diptera the males emerge from the pupa state after the females; I therefore believe that the females await the presence of the males, and, while waiting, pass the time away in aerial gambols." "Some time ago I witnessed a bit of malicious sport, in which the participants were fleas. I was observing a *Pulex* sleeping beneath the short hairs of a dog's axilla. My lense was a good one and I could clearly make out the body and limbs of the little sleeper. Suddenly there appeared another flea, which stopped short as soon as she discovered her sleeping comrade. She remained quiet for several seconds and then nimbly bounded on the others back. Clasping her body with her hind legs, she began vigorously 'to touzle the hair' of her surprised sister. She then sprang away into the thicker hair, closely pursued by the thoroughly aroused and evidently angry victim of her sport." The sport of ants and other animals is alluded to and the author expresses the opinion "that every living creature, at some period of its existence,has its moments of relaxation from the cares of life when it enjoys the gratification of true psychical amusement."

The Annual of the Universal Medical Sciences.[1]

The issue of the ANNUAL for 1894 is fully up to the high standard set by the earlier issues. Written for the practical needs of the busy physician who desires to keep abreast of the times, the principle of selection must obviously be immediate practical utility; and we are pleased to notice that a few carefully selected articles on morpho-

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[1]CHARLES E. SAJOUS, Editor-in-Chief. Published by *The F. A. Davis Co., Philadelphia*, 1894, 5 vols.

logical and theoretical subjects are regarded as embraced by this principle.

The editorial staff, so far as the articles on the nervous system are concerned, remains nearly the same as last year.

We can express our commendation of the work no better than by quoting (with the consent of the publishers) a few of the admirably prepared abstracts.

ALEXIA. A case designated one of "pure word-blindness" is described by HAISHOLT[1] occurring in a Frenchman 63 years old, a musician by profession, and, for several years, director of an orchestra in San Francisco. He was admitted to the Stockton Hospital for Insane on account of certain delusions of persecution. On admission, he was found to be free from any evidence of organic or functional motor disease or of sensory disturbance, except as to vision, and, to a slight degree, hearing. The ophthalmoscope showed left homonymous hemianopsia. He would sometimes ask the attendant to give him his other shoe, saying he could only see the right one, when both were before him. His speech was normal in articulation, he could hear and understand all that was said to him, he could spell verbally and write well to dictation, but he could not read what he had written, not even his own name. He also showed absolute visual amusia or note-blindness, being unable to read correctly a single note on the staff, though he could play from memory the most difficult music, with elaborate variations, with absolute correctness. He explained his inability to read as being due to a failure of his eyesight, requiring only suitable glasses. To humor him, dozens of glasses were tried, but, of course, without improvement. He died some eight months after admission from a purulent cystitis. At the necropsy, the brain, in its anterior aspect, appeared normal, but the occipital lobes on both sides showed extensive disease. The left occipital lobe was the seat of the old lesion, the whole lobe appearing of a yellowish-green color, sunken in appearance and the convolutions narrowed, the change in color and contour extending forward and upward into the angular and supra-marginal gyri, and inward along the median surface of the occipital lobe, the tip of which was quite softened. The posterior surface of the right hemisphere was of a yellowish-red color, and presented several hæmorrhagic spots, indicating a more recent and active disease process. The case is of interest and

[1] *Occidental Med. Times, Sacramento, Cal.*, Sept., 1893.

value, as confirming the accepted teachings of Wernicke as to the area representing speech, vision, and also the subdivision made by him into two types of cortical and subcortical alexia.

BECHTEREW[1] calls attention to the studies of his pupil, J. Meyer, showing the possibility of a new cortical localization. This writer has found that there are points in the cerebral cortex excitation of which produces contraction of the sphincters. The cortical centre acting upon the anal sphincter is slightly behind the crucial sulcus, on the external posterior portion of the sigmoid gyrus. That acting upon the vesical sphincter is in the external region of the posterior segment of the sigmoid gyrus, immediately behind the outer extremity of the crucial sulcus.

The presentation of a case of stuture of the median nerve to the French Academy of Medicine by BERGER started an interesting discussion on the method of the restoration of function in severed nerves. BROWN-SEQUARD, LABORDE, HERZEN, and HODGE have all taken sides either for or against direct reunion of the severed nerve fibres. The balance of opinion seems to be that the placing of the severed ends in juxtaposition simply assists the process of regeneration by preventing the formation of a cicatricial mass between the severed nerve-ends, which would prevent the new granulation tissue starting from the distal end reaching and occupying the sheath of the proximal end. The only portion of the proximal end that does not degenerate is the sheath of Schwann, and it is by this new tissue growing from the distal portion that the gradual recuperation is explained. Unfortunately, this does not explain the cases where the restoration of function is immediate, and therefore some of the observers claim that both methods may exist—the regeneration of all the fibres in the proximal end when the suture is tardy, and immediate union in those cases where the nerve-ends are brought into immediate opposition.

HEATH[2] and MOULLIN[3] each report a case of nerve grafting. The former employed two inches and a half of the posterior tibial nerve of an amputated limb to fill the gap in the ulnar nerve. Two months later there had been no return of function. In the latter case the sciatic nerve of a young retriever was employed to unite the sev-

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[1] *Revue internat. bibliographie, Beyrouth,* May 25, 1893.

[2] *The Lancet, London,* May 20, 1893.

[3] *Ibid.,* June 24, 1893.

ered ends of the musculo-spiral nerve, but there was only a very slight recovery of function.

DUNCAN[1] reports a case where the median and ulnar nerves were injured by incised wounds and were sutured, followed by recovery. The two ends could not be brought together without too much tension; so, after freshening the lower end, the bulbous portion of the upper end was split down the greater part of the way and sutured down to be united to the lower end, as shown in the figures.

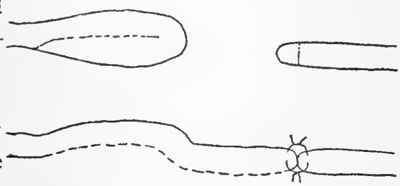

Fig. 9.
Suture of nerves. The upper figures indicate the position before suture, the lower figure after suture. The dotted lines indicate the incision. *Clinical Journal.*

Ladd's Psychology.[2]

Professor Ladd's new Psychology is one of the notable books of the year. His earlier works on Physiological Psychology are everywhere regarded as standard text-books or books of reference, even by those whose standpoint differs most fundamentally from his, and the present work by reason of its encyclopædic character and exhaustive criticisms will prove even more indispensable to such as desire an aid in keeping up with the currents of recent thought in these directions. Professor Ladd's standpoint is so well known that it will be necessary for us here to mention some of the more salient points only of the present volume. In it he has devoted himself exclusively to the exposition of the facts of human mental life, and he has succeded as well as could have been expected in making good his claim to have reserved the philosophical problems for another volume, though of course the author's metaphysical tendencies are sufficiently obvious.

In the two chapters of the Introduction the author defines his standpoint and discusses the Method, Sources and Division of Psychology. While he gratefully acknowledges his indebtedness to physiological psychology, yet the present volume is in no sense an exposition of physiological or experimental psychology. As to the use of experimentation, he takes the same ground as Binet in his recently

[1] *The Clinical Journal, London*, Dec. 21, 1892.

[2] LADD, GEORGE TRUMBULL. Psychology, Descriptive and Explanatory. A Treatise of the Phenomena, Laws and Development of Human Mental Life. *New York, Charles Scribner's Sons*, 1894.

published work that experiment belongs to truly psychological method only so far as it is constantly accompanied and tested by introspective examination of the phenomena of consciousness. He adds,—Experiment gives us preliminary information as to the definate physical and physiological *conditions* under which the psychic facts, as such, arise, change and pass away. But here, again, without introspection and trust in the introspective method, experiment gives us no psychical data or strictly psychological laws. So far many of our best experimental psychologists will agree with him, but he immediately proceeds to so narrow the field of experimentation that it would seem as if any really hopeful advocate of this method would have to part company with him. He says: "Only the simpler states of consciousness, in respect of their sensory and motor factors, readily lend themselves to study by the strictly experimental method," and the implication is that this method is now and forever must be practically fruitless elsewhere.

The body of the work is divided into three parts, Most General Forms of Mental Life, The Elements of Mental Life, and The Development of Mental Life. In his arrangement he has cut loose entirely from the traditional division into faculties and his whole treatment of the so-called faculties is admirable, though in some other respects he seems to have succeed less perfectly in disentangling himself from the old traditions.

The discussion of Attention in the concluding chapter of Part I is especially clear and suggestive. We are taught to regard primary attention as a form of psychical energy which necessarily enters into the determination of the character of every field of consciousness; in other words, it is a most general form of all mental life, and it is a necessary accompaniment of every truly psychic fact. This primary attention is present as a blind striving and selective, but self-originating activity in all the lower forms of conscious life, while, on the other hand, in its higher stages of growth it may reach the conditions necessary to intelligent, purposeful choice and thus become that voluntary attention whose cultivation and exercise constitute so important elements in all education.

The term conation is employed as correlative with sensation and feeling as one of the three primary states of consciousness. It may be considered as synonymous with the term "conscious striving" and as such it enters into all the most primary psychical states.

Professor Ladd has undertaken to write a text-book from the "genetic" standpoint, as the title of his third part again calls prominently to our notice. That the task set is by no means an easy one in view of the present meager knowledge of the actual development of mental life either in the individual or in the race, every one will admit. Even a small measure of success in this attempt should, then, be commended. The discussion of perception, as carried on by this method, leads the author to conclusions, some of which differ from those expressed in his Physiological Psychology. For instance, the intuitional or native element in space-perception is here thrown into the back-ground in favor of a more empirical view. He inclines to the belief that the incorporation of motor ideas into a given sensation-complex is necessary before there can be any true localization in space.

Among the most noteworthy and perhaps in many respects the most commendable passages in the book are those dealing with Will and Character. To that conscious striving which is the most elementary of all mental processes we have seen that the author applies the term conation, while *volition* is reserved for that more highly developed process which implies knowledge and feeling with reference to means end ends. To will, then, is the result of a development; it is something which no one can do at the beginning of mental life, but which all men learn to do in course of its unfolding. To exercise "free will"—in any conceivable meaning of this term—is not a birthright; it is rather an achievement.

Taking the volume as a whole, the most striking feature is certainly its extraordinary and unrelieved conservatism, a conservatism which is often thrust obtrusively forward, but which will nevertheless serve a good purpose in counteracting many of the extreme views now current. It is to be feared that in some cases this conservatism has gone so far as to defeat its own ends. In any case, it serves to foster a judicial spirit rather than to create and quicken enthusiasm. For these reasons, among others, the work will probably be found more useful as a book of reference for advanced students than as a text book for beginners.

C. J. H.

Kuelpe's Psychology.[1]

Külpe's Outline of Psychology is a work of some 475 pages clearly showing the influence of Wundt. The book deals with Psychology as a science. Its data are experiences and the difference between

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[1]Grundriss der Psychologie auf Experimenteller Grundlage dargestellt, von OSWALD KUELPE. *Wm. Engelmann, Leipzig, 1893.* Price 9 Marks.

Psychology and the natural sciences is simply "the dependence of these experiences upon living individuals."

It is quite erroneous to speak of the experiences of Psychology as essentially inductive. As a matter of fact, objectivization is peculiar to Psychology, as thought or feeling are.

Experimental Psychology avoids regarding the individual as a spiritual entity or an aggregate of faculties. The author does not find it necessary to declare for either the monistic or dualistic interpretation of the observed coincidence between psychical and physical phenomena but is satisfied with a statement of the parallelism.

Psychology is divided, as by Wundt, into a treatment of (1) the elements of consciousness, (2) the combination of these elements, (3) the condition or state of consciousness. Under simple elements of consciousness two classes are made to accommodate (1) the experiences which are definitely related to certain peripheral and perhaps also central stimuli, *sensations*, and (2) those which are not thus definitely associated with any bodily organs, *Feelings*. We think this distinction is largely a statement of ignorance, for it is most probable that the feelings are always intimately associated with characteristic forms of nervous agitation, though there may be no specific "centres" for the several modalities.

A brief review of the literature closes the introduction.

The first part is devoted to the Elements of Consciousness, beginning with the analysis of sensations. The properties attributable to sensations are equality, intensity, duration and extension though, of course, all need not be present in every sensation. The most important determinant in the analysis of sensations is the discriminating faculty or sensitiveness to differences.

The general conditions of sensation and discrimination are treated in fatiguing detail, attention, practice and fatigue are rubriced and sub-headed in true German style. The discussion of measurement of sensation is excellent as the subject is important.

Sensations are inherently incapable of measurement. Discrimination, on the other hand, supplies the lack. Like and unlike, present and absent are the two sets of judgments applicable. The statements "like" and "absent" are unambiguous, always having a constant value, but the other two are subject to great uncertainties. The amount of variation of stimulus with invariable sensation is a reciprocal measure of the discrimination.

The following abbreviations are suggested and used throughout the book, most of them already in use. The stimulus = r; difference of stimulus = D; discrimination threshold = S; threshold of stimulus = German S; [or we may substitute S1.] A stimulus used as a constant for reference is N, while another to be compared with it is V. mV is the mean variation derived from division of a series of observed errors by the number of observations. The less mV the finer the sensation and discrimination. Since relative and not absolute errors are most important $\frac{m V}{r}$ or $\frac{m V}{D}$ are used.

The sections devoted to the methods of gradual variation (Abstufungsmethoden) and error methods are full and clear enough for the student. For example, the method by minimal variation is thus illustrated.

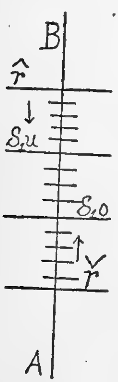

Fig. 10.

Upon the vertical A B the amounts of the stimuli are indicated from sub-observable (A) to super-observable (B). Beginning at $\overset{v}{r}$, r is varied till a judgment is reached that a sensation is present. This value S_1 o is noted on the diagram and the change continued until a decided sensation is reached, $\overset{A}{r}$. Now the stimuli are varied in the opposite direction until the subject decides that the sensation has ceased. This value S_1 u is recorded and $\frac{S_1 o + S_1 u}{2} = S_1$, or the threshold of stimulus. In a similar way the method of equivalence, method of minimal variation, method of super-perceptible difference, etc., are treated. The mathematical technicalities of the methods by error are briefly disposed of and stimulus and nerve excitement are taken up. The doctrine of specific energy of nerves is dismissed at once. No description of the anatomical and physiological elements of the nervous system is attempted. The theory of nervous translation, so dear to a Wundtian heart, accordingly does not appear. The discussion is but moderately well carried out.

The section on pressure sense shows a discriminating use of the recent papers of Dessoir, Goldscheider, Blix and others while it is not burdened with references or conflicting views. The vast system of subordinate qualities often built up upon the pressure sense is swept away and tickling, tactile sensnsations, pain and the like are all referred to complexes of qualities. Pain is not a special quality of the skin sense but a feeling which may result from the excitation of any sensory nerve. No reference is made to the theory which daily becomes more probable that pain is transmitted indirectly through the grey cornua of the cord by a species of nervous overflow.

Special skin centres for cold and heat as described by Goldscheider and Blix are rejected for, as the author acutely observes, common experience of the adaptation of the nerves on the existing temperature of the skin can hardly be harmonized with the idea of a special apparatus for both qualities of this sense. It is probable that there are special nerves for temperature sensation but that these may convey sensations of either sort. The reviewer ventures to add that the observed balance of hot and cold sensations over the existing condition of the skin as a zero point suggests that the two varieties of this sense are directly connected with vascular changes. The effect of extremes is identical and discrimination in any case is slow. This may be due to the readjustment of the calibre of capillaries. The close association of warmth and cold with pleasure and pain is in evidence as to a vaso-motor substratum for both. It has been observed that under spots especially sensitive to temperature a closer relation of nerve and capillary than usual exists. Again the path of temperature sensation seems to be like that of pain in the gray cornua and its centre in the gyrus fornicatus.

While little can now be said respecting smell and taste in the present state of our knowledge it seems to us that the treatment of hearing and vision in the book before us is exceedingly inadequate. The elementary student may justly expect from a work like this a fairly full discussion of theories of color vision. In this connection I may add that the elementary instruction in physiology in German schools seems painfully inadequate and the University system poorly arranged to remedy the defect. I have listened to quizzes in physiological psychology in the University of Berlin which betrayed ignorance of which an American freshman would have been justly ashamed. General sensation fairs relatively better. We are interested to note that tickling, etc., are referred to alteration in vaso-motor states. This may explain the close relation these sustain to pleasure-pain. The same remark applies still more forcibly to the sexual sensations whose close dependence on vascular changes is apparent. So shuddering and chilling are closely allied with those alterations in vaso-motor states which we hypothecate in case of ordinary temperature sense. The author does not hesitate to predicate a static function for the semicircular canals and finds anatomical proof of the connection of the n. vestibulars with the cerebellum.

The book is not happy in its explanation of the three interpretations of Weber's law but very truly states that Weber's law is a relation between stimulus and judgment and not between stimulus and reaction.

The treatment of "centrally excited sensations" is much more extended. It is recognized at once that the English associational doctrine that a reproduction differs from the original only in intensity and phantasy images sustain the same relation to reproduction makes any study of the quality of central sensation superfluous. Recognition is only a special case of discrimination, but recognition usually applies to images of perception, not those of memory. It is easy to see that recognition greatly modifies the effect of a reproduced presentation. A result of this is that abstract ideas are better remembered than concrete for they have been recognized more frequently.

To centrally originated sensations may be ascribed quality, intensity and spatial and temporal attributes. Under this head the author describes the two chief methods employed for determining them. That of Münsterberg is familiar; it consists of writing words in which some letters are blurred or omitted and by shouting a word having a suggestion implied causing the reader to firmly believe *Triest* is *Trost* or *Furcht* is *Frucht.* The words pronounced in the two cases were *Verzweiflung* and *Obst.* Various imperfections may be suggested which limit the application and trustworthiness of the method. The author's experiments were carried out by placing the observer for a long time in a dark room with instructions to report all visual impressions and his judgment as to their subjective or objective origin. In many cases great confusion resulted while the stimuli were small. In other cases all judgments were correct and no subjective sensations were experienced. The author thinks eye sensations, light flashes, etc., were excluded, but our own experience shows that a sensitive subject may have eye sensations with objective basis hours after the positive sensation. The real net gain by either method seems very small. A considerable section is devoted to a criticism of the Association doctrine. The frequent occurrence of spontaneous reproductions the author thinks is not sufficiently accounted for by unconscious or unnoticed connecting links of association. Again the chains of association contain many elements not before experienced. A picture makes an impression in its totality and it is difficult to discover that the associated concepts, etc., have any relation to elements contained in the picture. The subsumption of concretes under a general notion is not, according to the author, an association of such concretes with the general name.

Not only the qualities of sensations but their intensity and spatial and temporal extension influence central processes, but these variations have not necessarily been reproduced in the sense required by associationalism.

It is admitted that sensations which have once been together in consciousness form a tendency to reproduction in the sense that when one of them is again excited some one of the other similar sensations is accustomed to appear. The strongest tendency to reproduction is afforded by contiguity and succession. Attention increases the associability and reproductive power of sensations as do practice and fatigue.

It is less certain that pleasure and pain have this effect, for it is possible that they are only accompaniments while the increased attention is the real cause of the increase observed. Of course, after the treatment given to association we expect the will to play a great part in determining reproduction. The whole discussion is very "gingerly" and apprehensively conducted and brings us round to the point of departure with a curious flourish. The will is not one of the elementary qualities of the individual but the power of the individual to operate determinately upon his own conduct. Will and attention are closely associated and collectively constitute apperception according to Wundt. Apperception is not a metaphysical faculty but the name for an undeniable fact of consciousness. The author understands by will "the expression of the totality of previous experiences in all the gradations of force and value which these have attained through the general psychological laws, and equipped with the decisive power which characterizes the old and tried as contrasted to the fresh and new." Little of all this appears in consciousness. There is no doubt that such a power representing as it does the totality of past experience must furnish a marked condition for the nature of centrally arising sensations. This certainly betrays the influence of Münsterberg but how about the teaching af the author's own avowed master, Wundt? The spontaneous presentations do not owe their origin to any of the above conditions.

There follows a discussion of the theories of the immediate source of psychical processes, particularly those of central origin. The idea of special cells for each several sensation, etc., is repudiated as are the more recondite forms of psychical localization. Each sensation is not supposed to be limited to the action of a cell, but the sensation is the total result of the activity in a region of greater or less extent. The whole mystery of reproduction is explained by the use of Wundt's term, "functional disposition" (or predisposition as we should say.) A dynamic theory is substituted for the cell theory.

To this so far as its meaning is clear we heartily agree, but the idea has various "Bedenklichkeiten" and must be extended to its limit. The condition for all psychical processes (in consciousness) is interaction. One cell cannot generate a sensation even. It is the nervous interference which is the basis for thought. Not the number of cells but the complexity, variety and conductivity of the communicating fibres determines mind power. Now under these circumstances the search for a "seat of consciousness" is absurd. Nor would the discovery of a physical continuum help the matter at all. The last fact on this side is a form of activity, the first thing on the other is a modification of consciousness. The fact that the first form of activity resides in any place does not explain this origin of the second form which we call conscious. Only this must be admitted, that such connections must exist as permit the complexity of interaction which is the only known condition of the conscious process.

The extended and interesting passage on the feelings we may omit from the present review in the hope of referring to it in connection with the recent literature of the subject *in extenso*.

It is interesting to note that the sense of volition felt when striving against a corporeal or mental obstacle etc. is regarded by the author as a complex of more or less vivid organic sensations either of external or internal origin. These sensations are also accompanied by motor innervation. It is a little strange that the resemblance to feelings in this respect is not more clearly seen. In that case the nature of the intimate connection between feelings and will would be clearly revealed.

Sensations and feelings constitute the elements of consciousness and they may fuse and connect in all possible ways. Such combinations form the real content of consciousness, their elements being abstractions not isolated in experience. In the case cf musical tones the fusion may not reasonably be regarded as extra-psychical so that a really simple stimulus is perceived in the case of a chord, etc. Facts, however, seem to prove that this is not the case. The difficulties of a physiological explanation of this fusion drive the author to accept Stumpf's idea of specific synergy which nevertheless has so far found no concrete significance. [We might suppose, we presume, that when rates of repetition of the stimulus are properly related to the excitation in the various cells of a sensory these stimuli are superposed, being in like nodes, and that thus an irradiation is facilitated which is the essential physiological condition for pleasure, while on the other hand, irregularly recurring sounds cause a retardation in propagation and a summation which is the physiological basis of pain.] The discussion of affects, impulses, etc., follows Wundt closely not to say servilly. Nor do we find anything novel in the traditional discussion of space and time. As a text book is seems a pity that the work could not have afforded more detail in experimental matters that the student might catch a glimpse of the actual laboratory methods of the science. This factor is almost wholly excluded from the volume. In the third part is a practical repetition of the discussion of attention which closely follows Wundt in appearance. Of course the idea that the observed motor coordinations and sensory reflexes are *causes* of attention is repudiated but these are enumerated as conditions along with interest and the relation of an impression to the psycho-physical disposition. Ribot's theory of the evolution of attention is summarily dismissed and recourse is again found in Wundtian apperception. The question of the freedom of the will in the sense of absolutely indeterminate action is decided in the negative. Conditions for the choice may be unperceived but always exist. Apperception and will are fundamentally the same function. The apparent power ascribed to the will is derived from appperception. The work closes with a brief and colorless discussion of sleep, dreams and hypnotism.

Such a cursory glance as we have here given cannot fail to do any comprehensive work more or less injustice. But we have endeavored to give an adequate notion of the extent and tendency of the book and some hint of its method. While finding it wanting in illustrations of modern methods of research and prolix without being complete, and recognizing the limitations due to the preponderating influence of a single master we gladly recognize many valuable features which adapt it for use as a text book where the necessary perspective is furnished by the instructor.

C. L. H.

Cortical Alterations Following Section of Dorsal Spinal Roots.[1]

The results obtained may be summed up in a few words thus:

1. After section of the dorsal roots the excitability of the Rolandic zone is notably changed; and hence the integrity of the gen-

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[1]TOMASINI, S. L'eccitabilità della zona motrice dopo la recisione della radici spinali posteriori. *Lo Sperimentale,* XLVIII, 4, 1894.

eral sensibility is a necessary condition of the production of normal, provoked, movements.

2. In a first period, when the test is made soon after the cutting, the excitability of the Rolandic zone is increased,—an increase due probably to hyper-excitation of the spinal centres by the mere cutting of the dorsal roots.

3. The excitability of the cortical motor region diminishes sensibly when the excitation occurs some time after the cutting; and the excitable sphere of the motor centres is in this case restricted. This phenomenon cannot be ascribed to a degeneration of the muscles of the limbs, because the latter respond very well to the excitation of the sciatic.

4. The movements provoked by cortical excitation after cutting of the sensory roots are not coordinate. There exists a real cerebral ataxia; and they demonstrate the existence of a functional synergy between cerebral cortex and spinal roots.

5. These experiments contribute evidence in favor of regarding as sensory-motor centres those lying in the Rolandic zone.

G. F. MC KIBBEN.

La Conscience du Moi.[1]

This work is based upon Dr. Carus' now well-known book, The Soul of Man, which has already been noticed in these columns (Vol. III, p. lxvi). Many of the chapters have, however, been re-written and several new ones added for this translation, so that it may be considered practically a new book. The first chapter, which is one of those written expressly for this work, treats of The Nature of Consciousness. Consciousness is distinguished from substance and from movement, and when it comes to a positive definition we find ourselves on the familiar ground, " Consciousness is the state of our subjective existence." Consciousness as it exists in us is not merely an image of the external reality, but it is itself a reality. Consciousness is a thing *sui generis* and can no more be converted into force than force can be converted into matter. Though these three ideas are disparate, yet it does follow that once can exist without the other. Consciousness can exist only as the result of a particular activity of the brain. In this book the author has expounded, even more clearly

[1]Carus, Paul. Le Problème de la Conscience du Moi. Translated from the English by A. Monod. *Paris, F. Alcan* and *Chicago, The Open Court Publishing Co.*, 1893.

than in the earlier English work, his position as the advocate of that monism which "regards subjectivity and objectivity as two inseparable features of reality, consciousness being a complex form of subjectivity."

It is our purpose here to enter into neither an exposition nor a discussion of these philosophical theories, but rather to note certain points of physiological interest.

Chapter V, "Pleasure and Pain," has been re-written for this work. It is first remarked that moralists almost universally regard pleasure as an end in itself, as if the existence of feeling had no other purpose than the production of as little suffering and as much pleasure as possible. This proposition has never been proven. It has been very sagely treated as axiomatic. There was a time when the immobility of the earth was also regarded as an axiom. Pleasure and pain are in certain respects very inferior to the other psychic states. Neither pleasure nor pain possesses any representative value. They are simply subjective states, which contain no information as to the objective world. Thus they lack that element which alone can give dignity to mental phenomena. They are psychic in that they are states of feeling, but they are not mental; they are not symbols, they have no content; they are not parts or qualities of the human intellect. Pleasure is certainly not the end of man. The man who has attained the highest intellectual development subordinates the sensibilities to the service of the intellect. That familiar law of Dr. Bain's which identifies pleasure with an augmentation and pain with a dimunition of the vital functions and which figures so prominently in almost all of the text-books ancient and modern is dismissed on the ground that it is not sustained by the facts. Moreover the decay of the vital functions involves a dimished sensibility both to pleasure and pain. Suffering is always caused by a disorder, pleasure by the satisfaction of a need. Pleasure and pain are not opposites like cold and heat. They do not differ only in degree, but they are disparate.

Pleasure is falsely considered as active and pain as passive; neither is the activity of the flexors a proper characteristic of pain. Some pains are salutary and some pleasures are baleful. Pleasure and pain are inevitable, in that life consists of growth. Each advance causes some disorders which have to be repaired. Mr. Spencer's state of perfect harmony is an impossible dream, at least unless the great river of life is dammed up into a stagnant lake.

In the chapter on the birth of consciousness we are first reminded that, as a single feeling cannot alone call forth a true state of consciousness, but only their coordination, so there must be some place in the body in which the mechanism for this coordination may be effected. True self-consciousness arises only upon the occasion of a state of tension, or distinction of equilibrium among the various feelings. The concentration of feelings into self-consciousness has arisen under the influence of impediments to the free play of reflex movements.

Chapter X, on The Seat of Consciousness has been re-written. Dr. Carus' article in the September number of this Journal presents the substance of this chapter and the reader is referred to it for the detailed exposition.

C. J. H.

Invertebrate Morphology.[1]

This new text-book is adapted to the needs of students of some maturity, rather than to young beginners. The matter is arranged in a strict taxonomic order, so that the book may be used as a general text-book of invertebrate Zoölogy and as such it will doubtless find a wide usefulness in our colleges and other schools of higher learning. The attempt has been made to bind the facts of comparative anatomy together by such morphological bonds as will not only show the true relationships of the organisms, but also something of the rationale of the process by which the differentation has been effected. The book contains more of description than of explanation, as must necessarily be, in the present unsettled state of our knowledge. All of the theoretical questions centering about phylogenesis are today so hotly debated that a disappointing meagerness of positive morphological conclusions can be readily condoned if those which are chosen are carefully considered and based on sound principles. Professor McMurrich has succeeded in producing a book which, while taking cognizance of all that is best in current theory, yet maintains a conservative attitude and presents conclusions which may almost always be relied upon.

The new departures which probably first catch the eye of the reader are in the classification adopted. The invertebrates are divided into no less than twelve primary types. We find as distinct types the Prosophygia (Molluscoidea), Platyhelminthes, Nemathelminthes, Annelida, Crustacea, Arachnida, Tracheata, Protochordata. The latter

[1]McMurrich, J. Playfair. A Text-book of Invertebrate Morphology. *New York. Henry Holt & Co., 1894*, pp. 661.

includes, besides the Ascidiaceae, Cephalodiscus, Rhabdopleura, Balanoglossus, and Amphioxus. In the discussion of the phylogenetic relationships the evidence considered is of necessity more often embryological than paleontological, yet there are many places where the latter method might profitably have been made more prominent; in the discussion of the Mollusca, for example. The book may be warmly recommended as a real addition to the literature of the subject.

C. J. H.

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