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Comparative Study of the Nervous System.

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ILLUSTRATIONS OF CENTRAL ATROPHY AFTER EYE INJURIES.

With Plate I.

C. L. Herrick.

In the present paper it is not hoped to add anything new to the vast and daily augmenting literature of the visual connections but simply to place in accessible form some data accumulated, with the hope of ultimately making a careful study of the peripheral connections and particularly the central mechanism of accommodation. The difficulty of finding figures illustrating the actual results of the atrophies due to the destruction of the eye has disposed us to print our own diagrams with a running commentary. The material consists of serial sections of the brain of two rabbits whose eyes were operated on shortly after birth and before the eyes had opened. Series 292 is from a rabbit operated on August 25th, the right eye being removed. Killed November 1st, when nearly full grown. Series 297 is from a rabbit from which the left eye was removed September 19th, being then one day old. It was killed December 19th. As these brains were intended to compare with control series of normal brains and were to be used primarily in the study of the cells, etc., they were stained with sublimate hematoxylin and fuchsin. In both cases the loss of vision was complete and the wound closed by first intention without suppuration, though in one the globe of the eye and the muscular attachments were less completely destroyed than in the other. Unfortunately there was no opportunity for careful post-mortem examination of these conditions which can be inferred from the state of atrophy found in the sections. It will be seen that the atrophy in the optic tracts was much more complete in No. 297, that is in the one operated upon within 24 hours after birth, than in the other which was operated upon a few days later. We begin with No. 292, commencing behind the chiasm. The optic tract on the right side[1] is intact except that the innermost band of fibres is filled with granules to such an extent as to be decidedly darker than the ectal portions. The degenerate portion does not embrace more than a sixth of the whole. On the left side (that corresponding to the injured eye) the conditions are exactly reversed. The outer five-sixths is degenerate and filled with irregularly disposed granules, while the ental layer appears normal or nearly so. Under a moderate power (1-5 in. obj.) the difference between the degenerate and normal tracts is conspicuous. The unaltered portions have the nutritive granules arranged in regular files of 6-8 between the fibres and these rows are disposed at approximately equal distances. In the degenerate portions the granules are not only relatively more numerous but they are dispersed with absolute irregularity. The fibres are no longer approximately parallel but are irregularly meshed. The sheaths are partly dissolved and the myelin completely absorbed. (Cf. Fig. 11.) The tectum in this series is somewhat larger on the right side but there are no demonstrable histological differences.

Passing caudad to the level of the exit of the oculo-motor, we find the right root entirely absent while its fellow is normal. The right nidulus of origin is also absent while the interpeduncular niduli, which some writers persist, in spite of abundant evidence, in regarding as accessory third niduli, are intact on both sides. It is not possible to identify positively any of the elements of the missing nidulus though shrunken adendritic elements occur in the site. (Fig. 3.)

At the level where the interpeduncular nidulus ends caudad, the cells of the fourth nidulus appear in the sections and are more numerous on the right than on the left side. Still there is no conspicuous difference in this subject between the two sides. The dorsal longitudinal fasciculus becomes more concentrated at this point and the nidulus lies directly dorsad of it in a stroma of deeply staining material. There are about the

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[1] In discussing the sections it may be premised that the cephalic aspect of the section is presented so that the right side of the section is the left side of the figures.

same number of fibres in the root of the fourth nerve on either side. (See Fig. 4.) The external portion of the fourth nerve of the right side is apparently wholly degenerate while its fellow of the opposite side is intact. For some reason, then, the degenerative process has destroyed the central tract and nidulus of the third nerve but not those of the fourth, though the external part of the latter has disappeared. We find no central tracts degenerate between the fourth and sixth nerve niduli, but the latter has as completely disappeared as in the case of the oculo-motor. Nothing is left of root, tract or nidulus. The nidulus of the left side lies, as usual, just laterad of the genu of VII and its root tract turns sharply mesad beneath the VII fibres and then passes directly ventrad to the root. Some traces of the sheath may be found by careful search in the course of the root of the other side.

The result of the operation, then, has been as follows: (1) degeneration of the lateral three fourths to five sixths of the left optic tract and of the mesal one fourth to one sixth of the right tract, (2) proportional atrophy of the optic tecta, most marked on the left side, (3) obliteration of the nidulus, root tracts and roots of III and of the external part and roots of IV on the right side, (4) the obliteration of VI on the left side as completely as III. Negatively, the central portions of IV are unaltered and the interpeduncular niduli are intact.

The rabbit of series 297 was operated on earlier and the results are rather of the nature of atrophies than of degenerations. The diameter of the left optic nerve is somewhat more than one fourth that of the right. At the chiasm, as seen in Fig. 7, the proportions are about the same. The degenerated portions are almost completely absorbed leaving only atrophic phenomena. Sections further caudad show very distinctly the atrophy in the tract. (Fig. 8.)

At the proper level the corpus geniculatum of the left side appears with its tracts, but on the other side it seems quite absent. There are no degenerative changes to enable us to trace the tracts cephalad to the cortex but there seems no reason to doubt that they are atrophic throughout. The reduction in the tectum has gone on and perhaps nearly reached its limit. The left tectum is fully four times the size of the right but the intimate structure is not obviously different.

Passing to the oculo-motor apparatus, the third nerve roots are both present and it requires close examination to discover anything unusual in them but the fibres are atrophied to some extent. The niduli, on the other hand, are nearly completely atrophied. The cells are nearly all shrunken and shrivelled and lie in large perilymph spaces. The contrast between these cells and the unaltered cells of the interpeduncular niduli is instructive. (See Fig. 10.) In this case the fourth nerve has shared the fate of the third. While the atrophy has been more marked on the right side than on the left both are affected. The series unfortunately does not extend to include the sixth, but it is probable that the same condition existed in it. Our material is inadequate to illustrate the changes in the tracts and niduli of the second order.

In attempting to analyse the various alterations with which we here have to do it is necessary to distinguish degeneration from atrophy and aplasy, the latter being a failure to develop as a result of operative interference. See Singer and Munzer, *Denksch. Kaiserl. Akad. z. Wien.* 1890.

DESCRIPTION OF FIGURES.

Fig. 1. Transection of rabbit brain (No. 292) immediately cephalad of the optic tecta, showing the atrophy of the tracts of the left side. The section is not exactly transverse.

Fig. 2. Section through the tecta showing the atrophy of the left side and in the nidulus numbered "3."

Fig. 3. Section at the roots of the third nerves showing the absence of the right nidulus and root.

Fig. 4. Portion of a section through the fourth nidulus showing that it is not affected by the atrophy.

Fig. 5. Section at the exit of the sixth showing the absence of the fibres of the right side.

Fig. 6. Part of a section further caudad showing the complete atrophy of the right nidulus.

Fig. 7. Part of a transection of a rabbit brain (No. 297) from which the left eye was removed at birth, showing the degeneration of the right tract.

Fig. 8. A section further caudad.

Fig. 9. Section at the habenæ showing atrophy in tract of second order on the right as well as in the optic tract.

Fig. 10. Cells from the nidulus of the third (A) and from the interpeduncular nidulus (B) to demonstrate the atrophic changes in the former.

Fig. 11. Normal and degenerate portions of optic tract from 292, 8.

LECTURE NOTES ON ATTENTION.

AN ILLUSTRATION OF THE EMPLOYMENT OF NEUROLOGICAL ANALOGIES FOR PSYCHICAL PROBLEMS.

C. L. HERRICK.

At once a most difficult and a most important group of problems is offered in the study of attention. The importance grows, on one hand, out of the close connection of attention and its cultivation with the practical obligations of pedagogy, and, on the other, out of the theoretical relations of attention with fundamental mental endowments like volition and apperception.

The source of the difficulty is also two-fold; first, the attempts at experimental study of attention suffer from the ambiguity that, when all is done, the results are all apparently physiological rather than psychological. But this is only a conspicuous instance of what is true of experimental psychology as a whole. Care is necessary to discriminate the content in the mind from the physical accompaniments unless one is prepared to ignore that distinction entirely. The second difficulty is that different observers have different theoretical points of view and an unbiased stand-point is as impossible as it would be unproductive. The purposeless and indiscriminate collection of facts rarely furthers science. Working hypotheses and a willingness to reject them when evidence requires are the theoretically desirable conditions, though in practice the willingness to reject is on the part of some other observer or critic (none the less salutary in the result).

It seems proper to divide attention into (A) external or sensory and (B) internal or cognitional. This is merely a working division corresponding to the common experience that something may "catch the eye," on one hand, and that we "concentrate our thought" on a problem, on the other. It would seem that popular language has crystallized an opinion that in one case the process is passive and in the other active. We are slow to reject the calm and impartial dicta of common sense —in fact, in some sense, this dictum is likely to be found correct, though the meaning of active and passive in such connections may suffer a good deal as the result of analysis.

External Attention.—One of the first evidences of awakening psychical life in the child is seen in the motions of the eyeballs as he attempts to follow moving objects, and one of the last evidences that is given that the departing spirit still hovers over the threshold is the same seeking motion of the eyes. As the most direct and unbiased avenue to consciousness, vision is the best sense from which to study the phenomena of external attention. Now if the eye be fixed upon a given field of view coinciding with the visual field of the retina it is evident that all parts of the field are capable of producing an impression on the retina and so on the nerve fibres and brain; in fact, each such spot does stimulate a point in the brain corresponding to the spot in the retina on which it falls. This neural irritation is not yet in consciousness but is a part of the "content of sense," or sensory material for consciousness. Returning to the retina, if the field of view be uniform and uniformly illuminated and the gaze be fixed upon it under circumstances excluding other visual distractions a small disc will appear in the centre of the field of view which is somewhat more bright than the surrounding portions.[1]

This little experiment is the physiological aspect of the fact that there is in the axial pole of the retina a spot in which only the cones are present and consequently the intensities of light and shade are more vivid than elsewhere in the retina. This relation would lose most of its significance were it not for another relation connected with it.

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[1] The descriptions of most of the experiments accompanying the lecture are omitted as they are of such a nature as will readily suggest themselves to the experienced reader.

Experiment.—Fix the single eye upon a faintly illuminated screen with perforations near the margin of the field and a shutter behind in such a way that a ray of strong light may be revealed at will. Note that the axis of the eye involuntarily turns toward the illuminated spot. Vary the experiment by using small colored images painted with transparent color and projected upon a transparent part of the screen, etc. Now determine to resist this tendency and keep the eyes immovably fixed on the original spot. Observe whether there is a feeling of tension in the eye, a strain on antagonistic muscles of the neck or in the scalp or even a sense of tension in the brain. Interpret the results. Observe what happens when the subject is encouraged to expect the new impression on the right and then unexpectedly it appears on the left. A wider angle than the actual retinal one may profitably be used in these experiments while in other cases a diaphragm will be needed. In some it is an advantage to have the head fixed while it might be instructive in the deviation experiments in some cases to have the weight of the head counterpoised by braces under chin and occiput suspended to a swivel in the ceiling

What is the result if the eye is centred on a bright, a varying, or a barely legible object? Is there a conflict of interest?

We have then in the eye a device for differentiating a part of the field of vision by reason of which that portion is more vividly reproduced in the brain and we have an anatomical adjustment of the muscles of the eyeball to enable this sensitive point to be turned upon any object which, by reason of the inherent intensity, usurps the position. More than this, there is a very complicated system of nervous correlation reflexes which must have developed *pari passu* with the anatomical structure by which the visual coördinations are affected anatomically.[1]

It is of fundamental importance to decide whether the turning of the eye upon the vivid point in the margin of the field is due to volition or is spontaneous and a pure reflex. It seems certainly to be the latter. It may be noticed that in the fixing of both eyes on any field there is a complicated coördination which has to be learned but passes out of voluntary control, so far as the details of the process are concerned, very early. When any particular object is to be "fixed" in vision the two maculæ luteæ must be properly adjusted as "identical" spots of the retina and when this is done all other parts of the two images will fall on "identical" spots. Now when a bright or vivid spot appears near the margin of the field we might

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[1] The instructor will review the visual-motor coördinating systems.

assume that the effect is the same as that of a false accommodation of the maculæ and the instinct to correct it has potence to make the new accommodation before an act of judgment can adjudicate the question.[1] Whether this is an entirely satisfactory solution or not there is little doubt that external attention is of the nature of a reflex which may or may not retain a relation of subordinated connection with conscious processes. If careful attention is paid to what goes on during these involuntary acts of accommodation one may notice a certain sensation in the eyeball and muscles usually not felt at all. Now even where these sensational elements do not enter consciousness as such (or at all) they are stored up along with the retinal sensation and may be employed in the formation of a sense of position—a concept of a spatial nature. However obscure the mechanism of this process, there is no doubt that it takes place. When we exercise ourselves in the effort to mentally estimate the position of various objects in the field of vision seen by aid of momentary illumination and discover that this too is possible, it simply seems to mean that associations have been fixed between lateral cells in the retina and the muscle sensations produced in bringing an image on the macula lutea through the necessary arc to impose it on that spot.

Experiment.—Using a screen at a fixed distance from the eye the subject practices the estimation of distances until a degree of familiarity with the measures is obtained. Then in the dark try the same by instantaneous electric spark. Note accuracy. Tabulate results. Now try the same experiment varying the duration of the illumination and observe whether there is an optimum period and, if possible, whether the eye is moved. Compare the two methods of estimation, *i. e.*, that where the eye motions are used directly and those where they are used indirectly.

It is, then, obvious that the same class of sensations, viz. those derived from the act of accommodation, may be used in one case to produce a sense of effort or may become, in another, data for localization.

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[1] Compare the labored attempt of ZIEHEN to explain this point. *Leitfaden*, p. 134 et seq.

Experiment.—Glance casually over a page of print and note whether some phrase or word catches the eye. (The experiment is much more conclusive when done unintentionally). What word emerged? On repeating this experiment and glancing casually down the columns of the "Times" the writer caught the word "college" and "university" many times also the word "association" several times and hardly another word. A house keeper looking at the page of the "Youth's Companion" saw "cooking" and "sweeping" first.

The experiment may be conducted under scientific control in various ways. Arrange groups of figures similar in size and body of shade, most of them unfamiliar, one or more familiar, and reveal them for a short period (not too short), or produce familiarity by exposing squares covered by some one or more of the symbols as preparatory to the experiment. Note the effect of "association."

The result of these experiments convinces that the selection of one out of many impressions to be placed in the favored attitude in the sense organ is largely influenced by *interest* and *habit.* The word "interest" is here used in a popular and perhaps misleading sense. Probably in the sphere of the external sense these effects are all the result of habit. For example, the reason that my eye caught the words "college," "university," and "association" out of their places among others was certainly not the superior interest which these words have for me, for they emerged before there was any consciousness of the interest. True, I had often associated in mind these very words in interesting connections and had consciously gone about to seek these words or passages containing them with the mind "loaded," so to speak, for this particular game. The result is a habit of selection which retains its unconscious power. The number of cotemporaneous sensations received by any sense is purely a matter of the structural adaptability of the organ or its natural field. All of the impressions of a given field of sense may become the content of that sense and so may exert their appropriate effects in infra-conscious spheres of association, etc., even though only part of them ever reach consciousness. The discussion as to the possible number of cotemporaneous sensations is based on a misconception. Though the content of sense may be diversified only one thing is ever in the focus of consciousness at a given time.

So far we have been dealing with comparatively pure cases of external attention, but it is not to be denied that the conscious processes react on the sensory organs and modify their functions. It is a familiar commonplace that the degree of attention is very dependent on the feeling tone of a sensation. Two points are to be noted here: first, that the greater number of feelings associated with sense impressions have a practical value for the life of the individual and have so acquired an impulsive connection with external attention without calling consciousness into play; and, second, that the very nature of feelings involves intensity of the stimulus (summation, on one hand, and irradiation, on the other,) so that this comes under the head of intensity as above. But let us turn to another form of this activity. I resolve to attend to the excitations of some sense or, as we say, to keep eyes and ears open. This resolves itself into a more or less fruitless attempt to accommodate the organ voluntarily and results in for the most part ill-directed if not disturbing oscillations in the tension of the organ. Thus when in the night I strain the ear to catch a sound in no special locality I become conscious of the fact that the tensor tympani and stapedius muscles are making castanets of my ears and audition is impeded rather than facilitated; so when I strain if perhaps I can make out another star in a vacant space I lose more than one "dimension" before visible. One becomes conscious of a sense of effort in various organs, even in such as have no direct connection with vision and also of alterations in the somatic sensations. These sensations of effort, then, seem to us to prove the presence of attention, even voluntary attention, when there is absolutely no attention, for it is idle to speak of attention when nothing is attended to. It is only a cavil to say that in the case indicated there is attention to the sensations of effort. Such reasoning is an endless chain. When we really attend to something in the sensory sphere it is some specially selected anticipated thing. Even in the general case of listening for a noise we reproduce in thought one noise after another in advance. "It will prove to be a creak, or a scratch, or the like." Imagination meets the visual impression more than half way. "Is it a dagger that I see before me?" We are looking for something—our attention consists in the scrutiny of the content of sense with a reproduced vestige as a guide. The reproduction may be of a very simple sort, as that of number—we may be repeating mentally, simply "how many?" as we scrutinize the sense content, but it is easy to see that the state of things here is very different from that in case of external attention—we are now dealing with a complicated central correlation across if not wholly within the field of consciousness.

Internal Attention.—We have seen that internal attention popularly lays claim to active and conscious effort, but we have learned that such sense of mental effort may be, and sometimes is, simply the association of muscular sensations and that internal attention implies a variety of coördinations in consciousness and we need not be blamed if we fall to doubting the validity of the sense of self-direction in internal attention. Internal attention is connected with the process of comparison either of the content of sense with some vestige or concept, or of two or more psychical elements along themselves. Thus we receive the advices from sense with a predetermined interrogatory, it may be, "Is the new impression the same as some other? Does it belong to the same class? Was it previously associated with A, B, or C? Is it as big, as loud, as persistent, etc?" In other words, we compare the new sensation with some standard in reproduction and form more or less implicate judgements as to identity, similarity, difference etc., so that we find ourselves projected into regions in the very penetralia of the psychical life far from the supposed boundaries of mere attention. This experience is enough to show that attention is not a faculty or independent activity of mind. Inner attention then may be but the measure of the vividness of consciousness under different conditions and attendant circumstances, whether of presentations of sense or central processes. But, it is proper to ask, what then becomes of the appearance of voluntary direction of attention? If it were true that we can force our minds to attend to any thing we choose, then this would become a matter of volition and need not require a separate treatment. Very brief reflection shows that we cannot attend to anything we please, for, in the first place, it is necessary that the thing should be presented to consciousness. We cannot attend to a sensation not already a content of sense nor to an unreproduced reproduction. We can not manufacture a sensation to "attend to," but can we perhaps reproduce a vestige not in consciousness? It is evidently absurd. In the case of the various sense contents we have seen that some have special attributes of intensity or special reinforcing collaterals to adapt them to affect the higher centres. May it not be true that the vestiges of conscious processes (memory material) may have similar differential powers and special vehicles? The familiar fact that repetition facilitates reproduction shows that these vestiges are capable of being differentiated in their power of appeal to consciousness. Now experimentally let us undertake to recall the name of the man we met yesterday. "Think" as I may, no trace appears. I wrinkle the brow and strain all sorts of antagonistic muscles and set up a great sense of effort in the attempt to induce cerebral innervation, in fact, I do succeed in forcing an unusual supply of blood into the head and quickening the play of images but none of them is the right one. Try a new tack! The presentations originally responsible for all the disturbance were of —a person—a man—met yesterday—and we have exhausted the associational images called up by "man"—"name"— "Jones, Jenkins, Jaynes, etc." let us dismiss them and see what "yesterday" has to offer. The vestiges are fresher—they rush upon me—more trouble to dismiss the undesired ones. Certainly here they are! "Broadway—hospital ambulançe—Dr. B's clinic"—and, at last Dr. B. himself. What could be more simple, I have "recalled the name." No, but was not what I really did the inhibiting of the undesired reproduction in order to let the chain of association follow its own laws of appearance? Thus we seem to have reached Wundt's position that attention is essentially the results of inhibition. We cannot remain content with this conclusion for, first, practically, we are unable by introspection to find evidence of any such voluntary inhibition, second, theoretically, we seem to have gained nothing by such an assumption for the source and nature of the volition involved is as obscure as ever. What is certain is that consciousness hovers from point to point in accordance with laws some of which we are able to formulate, if not to explain. Before leaving this point we meet the apparently legitimate criticism that what has been said applies rather to reproduction than to attention. Attention, it may be said, is not responsible for calling data to consciousness but for retaining them when there. However, observe that, if the conclusion that only one datum can be in consciousness at once be correct, experience shows that it is impossible to keep attention fixed for the fraction of a second on absolutely one presentation. There is a constant flux and alteration. Attention becomes then a set of rapidly repeated reproductions. In thinking intently of one thing we limit the field of oscillation and cut off distractions as much as possible, but the oscillations with the various resulting associations continue and give pregnancy to the meditation. Here again inhibition emerges as the agent of attention. Here too we are forced to reject the interpretation as above. The sense of voluntary effort in attention we may agree with Ziehen in ascribing to sensations of innervation, etc., that in no sense are a cause of the attention. But we would not stop there, but believe that the sense of personal participation in our activities is of a more complex character than that suggested by the Münsterberg-Ziehen school.

To understand attention then one must understand the nature of consciousness. From its psychological side this is confessedly insoluble and we must be content either to pursue our search no further or to accept such suggestions as may come from neurology and philosophy. In taking the latter course we are frankly entering a theoretical domain where only a balance of probabilities and reasoning from analogy can serve us.

The organ of consciousness is the cerebrum and the great and distinguishing character of the hemispheres is the unlimited associational mechanism. All sorts of lower neural processes which are to influence consciousness have their offices here but these stations are all connected with each other. From all that we know of the analogies of nerve force it does not seem inherently impossible that a current from an eye centre might if permitted to reach an auditory cortical station, produce some sensation—perhaps of a new kind of sound. The anatomical relations prevent an interference of this kind but the results of the current's action on the eye station may meet and modify a similar product of an ear station in a centre of a higher order. In the frontal lobes, perhaps, is a projection system of the highest order where the last fine adjustments occur. There must be, it would seem, a constant balance or resolution of forces in such a system. The centre of tension, if it could be seen, would be found flitting with greater rapidity that the reflected disc of the electrometer of a testing outfit from one station to another in obedience to the various disturbances of equilibrium—due here to a new sense presentation, there to a nutritive adjustment removing a temporary inhibition. There is, to all appearance, only this sort of physiological unity possible. The only psychological unity is the unity of consciousness. Is there a connection between the two? We are inclined to answer in the affirmative. While it seems necessary from considerations not necessary to enter upon here to consider consciousness itself a spontaneity of a higher than nervous nature, it is apparent that it finds its physical condition in this vortex or nervous "centre of gravity." If this or something like this is the truth about consciousness, then attention is a name for the play of consciousness and a study of its laws reduces, on one hand, to the investigation of neural equilibrium and, on the other, to a natural history of consciousness. The conditions of inner attention are those of association and inhibition.

A NOTE ON THE CEREBRAL FISSURATION OF THE SEAL (Phoca vitulina).[1]

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The specimen was not more than one year of age, and came into my possession in November, 1895. During the manipulation incident to the process of hardening some general resemblance of the fissural pattern to that of the feline or canine type was noticed. The pia was removed and the fissures studied at an intermediate stage of the hardening before their walls had lost their pliancy.

Dr. E. C. Spitzka (1890) in a preliminary paper (American Naturalist, XXVI, 115-122) refutes some rather grave misrepresentions by Theodor, 1887 (Das Gehirn des Seehundes, Inaugural Dissertation) one of them being the existence of a so-called *Commssura Suprema* an elongated transverse mass of fibers lying dorsal to the Callosum, an artifact pure and simple. Theodor further states that "the Seals and (ordinary) Carnivora are in their cerebral organization today widely separated and their common origin must be sought in a remote geological period." In regard to this Spitzka states that the examination of a series of brains beginning with the mink, the fresh and salt water otters and passing through the eared to the earless seals would show about as beautiful a transition as a morphologist could well desire.

In the specimen at hand the frontal region of the brain is very much fore-shortened and gives the appearance of considerable width. On the lateral aspect the Sylvian fissure is well marked and pursues its usual dorso-caudal course. Just in front of it and extending vertically (dorso-ventrally) is another un-

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[1] Read at the Meeting of the American Anatomists Dec., 1895, Philadelphia, Pa.

named fissure which superficially seems to run into the Sylvian at its base. This vertical fissure Spitzka has taken for the Sylvian. He describes it as follows: "It is the enormous hypertrophy of this field (auditory cortical) which crowds the Sylvian into its unusual vertical, nay anticlinal position." The blunt frontal end of the cerebrum is an additional reason for making the above condition possible but this view leaves a well marked fissure in the usual situation of the Sylvian unaccounted for. This opinion is still more difficult to accept when we come to "sound" the fissures (examine their depths). The vertical and the true Sylvian fissures meet superficially at the latero-ventral angle of the cerebrum and if the sides of the Sylvian be separated, it will be seen that the vertical fissure instead of directly joining the Sylvian becomes a submerged fissure, at this point corresponding to the preopercular area of the human brain, and crops out again on the ventral surface on the front or cephalic wall of the mouth of the Sylvian. In reality the vertical is an open surface fissure in its dorsal half and overlapped by the cortex (supergyre) in its ventral half. This condition is found on both sides.

Tiedemann (Icones cerebri simiarum et quorundam mammalium rariorum, Hidelbergia, 1821), in a figure of the base of the seal's brain shows the ventral outcropping of a fissure in the cephalic wall at the base of the Sylvian which is none other than the terminus of the vertical. The present specimen confirms this exactly.

In the feline brain the fissure approximating most nearly to this vertical fissure of the seal would, in my opinion, be the anterior fissure; for if the frontal region of the cat's brain could be moulded by any process of growth to the relatively fore-shortened condition of the seal's brain the parts would assume very much the same relations. The *fissura postica* of the cat's brain does not seem to be represented in the seal.

The super-Sylvian and the post-Sylvian are well marked. The two are continuous with each other at the surface on both sides; but at their union two branches are given off on the left hemicerebrum and one on the right hemicerebrum. The presence of subgyres at this point makes it very difficult to get accurate soundings; and whether the union of these two fissures is anything more than superficial is therefore somewhat uncertain.

The lateral fissure is long and tortuous and well on the dorsal surface; its average distance from the intercerebral cleft being about one centimeter. On the left side it unites superficially with the super-Sylvian at the level of the vertical anterior fissure. On the right side the union is deeper and in advance of the anterior. The caudal termination of the lateral fissure is at the extreme end of the crebrum and is in the shape of a T due to the union of a small transverse fissure, possibly the lunate of the cat.

The ansate is a well developed fissure and is almost directly vertical in its course. It arises within less than a centimeter of the mesal surface caudal to the cruciate and extends ventrally to about the level of the superficial confluence of the anterior and Sylvian fissures. On each hemicerebrum there is a superficial union of the super-Sylvian with the ansate but in each there is evidence of a shallow (vadum) between them.

The diagonal of the cat is not distinctly represented in the seal, unless on account of the very much foreshortened condition it has become confused with the ansate or cephalic portion of the super-Sylvian.

The super-orbital fissure arises from the base of the olfactory bulb, which covers its origin, and extends in an oblique ventro-caudal direction to within one half a centimeter of the basi-Sylvian.

The olfactory is a very short but deep fissure in which the delicate olfactory crus is almost completely imbedded.

The cruciate fissure of the right side extends for a distance of a centimeter and a half on the dorso-lateral surface and has considerable depth. It also extends a centimeter and a half on the mesal surface. Very near the dorso-mesal margin a dorsal branch is given off and nearly opposite this is a ventral branch.

The left cruciate fissure extends less than one centimeter on the lateral surface, but a minor fissure connecting with it superficially makes it apparently extend over two centimeters. As with the right hemicerebrum a dorsal and a ventral branch are given off on the mesal surface, near the dorso-mesal margin. The cruciate continues superficially as far as the splenium with a fissure corresponding to the super-callosal. A super-callosal seems to be represented on the right side, but it does not join the cruciate.

The splenial fissure arises at the dorso-mesal margin of the hemicerebrum at about the level of the splenium. It is oblique in its direction (ventro-caudal) and is more vertical than horizontal. It extends well on to the ventral aspect (about one centimeter).

In the dog and cat cerebrum the fissures are for the most part isolated and distinct ; but in the seal there are numerous branches given off and rather an unusual amount of confluence of the larger fissures. The complexity is increased by the sinuous course and the presence, below the surface, of numerous subgyres or outgrowths along one wall, while the other wall overlaps and becomes more or less concave in adapting itself to this growth. This sinuosity at the depth of the fissure (much more marked than at the surface) makes an accurate sounding well-nigh impossible. The obliquity of the fissures and the overlapping of one wall by the other, especially in the case of the ventral portion of the splenial amounts to almost an operculum or poma. These conditions in many regions render the accurate determination of a fissural integer very difficult.

Underlying all there seems to be a fissural pattern not unlike that of the feline to which are added the various complexities above enumerated, but these are hardly sufficient to obscure the carnivore type.

PLATE II.

REFERENCE LETTERS FOR THE FISSURES.

ans.—ansate.
ant.—anterior.
Cal.—callosum.
Con.—confinis.
Cor.—coronal.
Cr.—cruciate.
Diag.—diagonal.
l.—lunate.
lat.—lateral.
m.—marginal.
ml.—medilateral.
Post.—postica.
P. Syl.—post-Sylvian.
rh.—rhinal.
sc.—supercallosal (?)
so.—superorbital.
spl.—splenial.
Sp. Syl.—super-Sylvian.
Syl.—Sylvian.

EXPLANATION OF FIGURES.

In all of the figures the important fissures are drawn with heavy lines and the minor fissures with light ones. The first four figures were photographed and enlarged drawings made. A small cross indicates a shallow depth of the fissure at that point. The fissural names are based upon those used in the Anatomical Technology (Wilder and Gage).

Fig. 1. Lateral view of the left hemicerebrum of the seal.

Fig. 2. Mesal view of the right hemicrebrum.

Fig. 3. Lateral view of the right cerebrum.

Fig. 4. Mesal view of the left hemicerebrum.

Fig. 5. The base of the seal's brain, after Tiedemann. This figure shows the ventral outcropping of the vertical anterior (?) fissure in the cephalic wall of the Sylvian.

Fig. 6. The dorsal aspect of the seal's brain, after Tiedemann.

Fig. 7. Lateral aspect of the left hemicerebrum of the cat (diagrammatic).

Fig. 8. Mesal view of the cat's right hemicerebrum (diagrammatic).

Fig. 9. Schematic type for brain of Carnivora, after Pausch.

Fig. 10. A cross section of a fissure, to show the obliquity.

Fig. 11. A diagram to show the difference in the course of a fissure at its surface and depth. The heavy lines represent the fissural walls at the surface. The dotted lines and arrows represent the deep course of the fissure.

MORPHOLOGY OF THE NERVOUS SYSTEM OF CYPRIS.

C. H. TURNER.

With Plates III—VIII.

Introduction.

About three years ago, on publishing a "Preliminary Note on the Nervous System of the Genus *Cypris*," I promised to publish, in the near future, a histological monograph on the Ostracoda. This paper is intended as the first installment of such a monograph. In this communication it is intended to give a detailed discussion of the central and peripheral nervous systems of the *Cypridæ*.

Owing to its large size, *Cypris herricki* Turner has been selected as the type to study. To eliminate all mere size-variations, *Cyprinotus incongruens* Ramdohr has been used as a check. For the study of the central nervous system, these two species have been considered representative types of the *Cypridæ*; but, in studying the peripheral sense organs, use has been made of all accessible genera. These genera are: *Candona*, *Cyclocypris*, *Cypria*, *Cypris*, *Cyprinotus*, and *Cypridopsis*.

This paper being the embodiment of neurological investigations, any prolonged discussion of extra-neural systems would be out of place; yet, in order to facilitate a comprehensive discussion of the nervous system, a few terse histological statements upon the associated systems have been made.

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HISTORICAL RESUME.

Among the legions of histological monographs that recent instruments and improved technique have called forth, those on the neurology of the *Ostracoda* form an all but insignificant part. To the best of my knowledge the first to write on this subject was Leydig. He described the peculiar seta found on the second joint of the antenna and called it a sensory seta.

Then followed Dr. Carl Claus, who, in 1860 (1) discussed these same setæ and called them "*blasse Kolben und Cylinder*" or "*Leydische organe.*" In 1865 (2) the same author discussed the eyes of *Cypridina*, laying special stress upon a simple eye which occurs in front of the paired eyes, because he thought that the presence of that eye renders quite probable the hypothesis that the compound eyes of the *Cypridæ* are analogous to those of the *Cladocera*. According to Dr. Claus this median simple eye consists of three layers; 1st, an outer transparent lens; 2nd, an inner nervous layer; 3rd, an intermediate pigment layer. Both in form and position the outer portion of this eye resembles the lens of the *Heteropod* eye. The non-pigmented striated portion, into the substance of which nerve fibres penetrate, contains elongated cells. Later Dr. Claus (5) showed that in *Cypridina* the size and position of the paired eyes serve to differentiate the sexes. In the males, the paired eyes are almost in the middle of the shell, while the much larger, unpaired, median eye is imbedded in a swelling of the forehead. In 1891, Dr. C. Claus (6) stated a theory concerning the compound eyes of the *Ostracoda*.

Dr. Rehberg (9) also has contributed something to further this cause. Among other things he has minutely and accurately described the tip of the second foot of *Cypris*. In his eyes, this member is something more than a leg functioning as an ovipositor, for in its tip it bears a sensory organ which is probably auditory in function. In addition to this he has described, in the following manner, the sensory seta found on the third joint of the antenna. This sensory seta consists of: 1st, a chitin-surrounded proximal portion; 2nd, a short transparent middle-piece; 3rd, a granular knob-like distal portion. Its nerve enters through a hole in the chitinous exoskeleton.

Later Dr. Lang (8) summarized the accessible literature on the central nervous system of the *Ostracoda* in the following words: "The ventral chain of *Cythere*, which follows the brain and circum-oesophageal commissures, is said to consist of an infra-oesophageal ganglion and four subsequent ventral ganglia. The infra-oesophageal ganglion is said to show its composition out of two ganglia and to innervate the jaws, while the three subsequent ganglia give off nerves to the limbs, and the last ganglion, nerves to the most posterior divisions of the body and the genital apparatus. In contrast with the above, the ventral chain of *Halo-*

cypris appears much concentrated. It consists of an infra-oesophageal ganglion, with nerves to the jaws and maxillipeds, and a small ventral ganglion. Out of the latter arise two pairs of nerves, which probably innervate the musculature of the limbs and the abdomen.

Finally comes Wenzel Vávra who, in his late work (11), has devoted three pages to the discussion of the nervous system of the *Ostracoda.* In that work he makes the following statements: 1st, the central nervous system consists of a brain and a five-ganglionic ventral chain; 2nd, the optic and antennulary nerves arise in the brain, but the antennary nerve arises in the pharyngeal collar; 3rd, in the five-ganglionic ventral chain which extends to the genital apparatus, the anterior three ganglia are closely approximated; 4th, from each ganglion a nerve passes to a pair of limbs and from the last ganglion a nerve passes to the genital apparatus; 5th, what Dr. Claus says about the structure of the eye is correct; 6th, in *Cypria* and *Cyclocypris* the eye is large and the pigment black, in *Candona* the eye is inconspicuous and the pigment reddish; 7th, in *Typhlocypris*, although the eye of the embryo is pigmented yet the eye of the adult is a degenerated, non-pigmented, sense organ; 8th, in *Notodromas* the three eyes are separated, but each of the paired eyes is connected, by means of a stalk, with the median eye, and each of these three large eyes receives a distinct nerve from the brain; 9th, the sensory seta of the second antenna, which is longest in *Typhlocypris, Candonopsis* and *Cyclocypris*, is an olfactory organ; 10th, the "blasse kolben" on the last segment of both the antennules and antennae are composed of two segments; 11th, on the fifth segment of the antenna of male and female specimens of *Notodromas* there occurs a special sensory seta; 12th, in *Candona, Candonopsis,* and *Cypria* the distal extremity of the fourth segment of the male antennae bears a characteristic seta.

TECHNIQUE.

For hardening and fixing *Ostracodes* alcoholic picro-sulphuric has proven the best fluid. This fluid is compounded in the following way:

70 per cent. alcohol, . . .	100 vols.
Sulphuric acid, conc.	2 vols.
Picric acid, as much as will dissolve.	

For the above formula I am indebted to Dr. J. Playfair McMurrich, now of Ann Arbor. Since this fluid sometimes causes thin shells to curl, it is not so good for museum specimens as 70 per cent. alcohol; but for histological work it is excellent. It does not injure the tissues, it penetrates chitin easily, and it fixes the cell structure. The living specimens were placed in this fluid and allowed to remain for at least twenty-four hours. Then after being washed in 70 per cent. alcohol until all the picric acid had been removed, they were either transferred to the stain or else, after being hardened and sectioned in the usual way, they were stained on the slide.

Among the numerous stains tried were: Kleinenberg's hæmatoxylin, Delafield's hæmatoxylin, Czokor's alum cochineal, borax carmine, eosin, etc., but none of these gave satisfactory results. Finally Ehrlich's hæmatoxylin and tincture of alum cochineal were tried. Both of these stains gave good results. In using both of these stains the specimens were stained in toto. When Ehrlich's hæmatoxylin was used, the specimens were overstained and then washed out with acidulated 70 per cent. alcohol; but when the tincture of cochineal was used, after remaining in the stain for about twenty-four hours, the specimens were washed in 70 per cent. alcohol and then hardened and sectioned in the usual manner.

PRELIMINARY.

Although a lengthy discussion of the histology of extraneural systems would be foreign to the purpose of this paper, yet, in order to facilitate a comprehensive description of the nervous system, it is thought best to give a brief description of the internal parts of the *Ostracoda*.

All previous writers to the contrary notwithstanding, the shell of the *Ostracoda* consists of three layers: an ectal layer, which has been hardened by the deposition in it of calcium carbonate; an ental, thin, flexible layer; and an intermediate layer of connective tissue [fig. 1]. Where the shell is united to the body the ental layer is absent [fig. 1, 6]. The connective tissue in the shell is a continuation of the connective tissue of the body. Most of the space between the ental and ectal layers not occupied by the connective tissue, is filled by the gonads and lateral evaginations of the mid-gut.

The body proper consists of two regions, a broad cephalothorax and a narrower abdomen. The abdomen is movable on the cephalothorax [fig. 9]. Seven of the eight pairs of appendages arise from the cephalothorax, while the remaining pair (the abdominal rami) arises from the caudal extremity of the abdomen.

From near the dorsal extremity of the cephalic margin of this creature arise the antennules and from a little below the middle of the same margin arise the antennae. Passing caudad, from the ventral margin arise, in quick succession, the mandibles, 1st maxillae, 2nd maxillae, 1st leg, 2nd leg.

The mouth, which lies between the mandibles, is bordered by an unpaired upper and by paired lower lips. These, together with the mandibles, not only triturate the food, but serve also as the locus of three pairs of sense organs [fig. 16]. The short oesophagus, which is bordered with large cells [fig. 9c], extends almost vertically dorsad into the fore-stomach [fig. 9]. In the walls of this grinding apparatus cells can be seen. Now follows the stomach, from the walls of which lateral evaginations project into the shell. The wall of this stomach is composed of a single layer of columnar cells [fig. 37,41]. The dorsal portion of the stomach is quite large, extending from the cephalic extremity of the cephalothorax to the beginning of the abdomen [fig. 9, 16]. The intestine extends through the abdomen to the dorsally located anus, which is situated near the abdominal rami [fig. 9].

The ovaries lie between the shell layers. After entering the body on the dorsal side just caudad of the abdomen and thence passing ventrad into the abdomen, the sexual ducts pass ventro-meso-caudad to the median unpaired vagina, which lies on the ventral side near the abdominal rami. The walls of the abdominal portions of the sexual ducts are quite glandular. They secrete the chorion of the egg.

Near the ventral side of the body there is a broad chitinous exoskeleton [fig. 1, 5], to which the muscles of the extremities are attached.

Surrounding all the organs of the body (nervous system included) we find a mesenchyme-like connective tissue. This connective tissue consists of membranous and fibrous cells, among which are scattered larger and denser irregularly shaped cells [fig. 1, 11].

It is important that no one should suppose that the above description is intended as an exhaustive histological study of the *Ostracoda*. Although it contains some points that have not yet been brought out by other investigators, nevertheless, it is given merely to facilitate an intelligent description of the nervous system and its relation to the extra-neural systems.

The Central Nervous System.

The central nervous system of *Cypris*, like that of the higher crustacea (*Malacostraca*) is composed of a supra-oesophageal ganglion which is united by a pharyngeal collar to a multiganglionic ventral chain. This is true, not only of *Cypris*, but also of *Cypridopsis*, *Cyclocypris* and *Candona*. When we recall that Dr. Lang states that in *Cythere* and *Halocypris* this is also the case, we have grounds for believing that in all *Ostracoda* the central nervous system consists of a supra-oesophageal ganglion which is united to a ventral chain by a pharyngeal collar.

Supra-oesophageal ganglion.—This ganglion lies about half way between the dorsal and ventral surfaces of the body and between the oesophagus and the cephalic border of the body. It lies just below the place where the oesophagus enters the midgut. In my preliminary paper the statement was made that this ganglion was much nearer to the dorsal than to the ventral surface. This was a misprint; the ganglion usually lies nearer the ventral than the dorsal surface. This is a compound ganglion. Although small, yet this supra-oesophageal ganglion is probably compounded out of seven distinct ganglia. These problematic ganglia are: three ganglia that have fused to form the unpaired optic ganglion, two antennulary ganglia, and two antennary ganglia.

The optic ganglion is located in the roof (dorso-cephalic portion) of the supra-oesophageal ganglion. Although in the adult it is a median unpaired structure, yet its histology seems to indicate that it is a triune structure. The optic nerve arises from the apex of this ganglion. In *Cypris* and the allied forms examined by me, the optic nerve is a single unpaired nerve; but in *Notodromas*, according to Wenzel Vávra, three optic nerves arise from the brain. The fact that in *Notodromas* three nerves arise from the optic ganglion lends support to the view that this is a triune ganglion. However, we must look to embryology for a final settlement of this question, and the necessary data are not at hand. Wenzel Vávra has called this portion of the supraoesophageal ganglion from which the optic nerve arises the fore-brain.

The paired antennulary ganglia occupy the lateral portion of the supra-oesophageal ganglion [fig. 10]. Wenzel Vávra has called this portion of this ganglion the mid-brain. From the dorsal portion of each side of this ganglion, arises a nerve.

Further ventrad, but nearer the meson, in the lateral portion of the supra-oesophageal ganglion lie the paired antennary ganglia [fig. 10]. A portion of this ganglion lies in the pharyngeal collar. Wenzel Vávra has called this portion of the ganglion the hind brain.

The supra-oesophageal ganglion is connected, by means of a pair of circum-oesophageal commissures, with a sub-oesophageal ganglion [fig. 16, 42]. These commissures pass obliquely backwards and downwards (ventro-caudad) from the lateral portion of the supra-oesophageal ganglion to the corresponding portions of the sub-oesophageal ganglion. These two commissures constitute the pharyngeal collar. This collar is not merely a commissure but it is also the locus of a nerve centre. All along its front (cephalic) border extends a chain of ganglionic cells. The chain of cells is a portion of the antennary ganglion [fig. 3].

As in all invertebrate nervous systems, so here, the central nervous system is composed of two things: nerve cells and neuroglia ("Punktsubstanz" of Leydig, "Marksubstanz" of Dietels and Rawitz, "central Nervennetz" of Bellonci and Haller). In the supra-oesophageal ganglia of *Cypris* the nerve cells are aggregated in the dorsal, cephalic, ventral and lateral portions of the periphery, while the neuroglia is central.

Ventral Nerve Cord.—In his comparative anatomy, Professor Lang has said: "The ventral cord of *Cythere* which follows the brain and oesophageal commissures is said to consist of an infra-oesophageal ganglion and four subsequent ventral ganglia. The infra-oesophageal ganglion is said to show its composition out of two ganglia and to innervate the jaws, while the three subsequent ganglia give off nerves to the limbs, and the last ganglion nerves to the most posterior division of the body and genital apparatus. In contrast with the above, the ventral chain of *Halocypris* appears much concentrated. It consists of an infra-oesophageal ganglion, with nerves to the jaws and maxillipeds, and a small ventral ganglion. Out of the latter arise two pairs of nerves, which probably innervate the musculature of the limbs and abdomen."

Morphologically the ventral chain of *Cypris* is intermediate between these two extremes. It is more concentrated than that of *Cythere* but not quite so compact as that of *Halocypris.* In this case the ventral chain consists of an infra-oesophageal ganglion and two subsequent ventral ganglia. All of these nerve ganglia are connected, not only by two longitudinal commissures, but also by straggling chains of nerve cells [fig. 32, 42]. To repeat, the ventral chain of *Cypris* is composed of three pairs of ganglia, which are united by commissural fibres and nerve cells.

Now Wenzel Vávra has recently stated that the ventral chain of *Cypris* is composed of five ganglia. At first blush these two views seem to be irreconcilable. However, when critically compared, the two views are not so antagonistic as they seem. Dr. Wenzel Vávra confesses that "*Die ersten drei Ganglien stehen sehr gedrängt.*" Although in the adult the sub-oesophageal ganglion of *Cypris* is an indivisible unit, yet my investigations lead me to believe that it has been compounded out of at least three pairs of distinct ganglia. Now if by saying that the first three ganglia are closely compacted Wenzel Vávra means that they are compacted sufficiently to form a triune ganglion then our views harmonize.

From this compound ganglion arise the following five pairs of nerves: nerve of the upper lip, mandibular nerve, nerve of the lower lip, thoracic nerve.

The two halves of this ganglion are connected by three transverse commissures.

The first pair of ganglia behind (caudad of) the sub-oesophageal ganglion gives off a pair of nerves to the second maxillae.

From the last ganglion arise two pairs of leg nerves and one unpaired abdominal nerve.

In the region of the sub-oesophageal ganglion the ventral chain lies above (dorsad of) the endoskeleton, while back of that region it lies below (ventrad of) the endoskeleton.

In the region of the sub-oesophageal ganglion the nerve cells are confined to the ventral and lateral surfaces of the ganglion, while in the rest of the chain, the nerve cells occupy all of the periphery and also the mesal plane.

Root ganglia.—At the origin of certain nerves there is a mass of ganglion cells. The ganglion is often quite intimately united with the central nerve chain.

NERVES.

The principal nerves of *Cypris* are: the optic, the antennulary, the antennary, the labial, the mandibular, the labral, the two maxillary nerves, the thoracic, the two leg nerves and the abdominal nerve.

Optic Nerve.—The optic nerve arises from the apex of the optic ganglion, which is also the apex of the brain. In *Cypris, Cyprinotus* and allied forms examined by me, this is a median unpaired nerve. At a distance from the brain which varies in different species, this nerve splits into three branches—one for each of the divisions of the median tripartite eye. Passing upwards (dorsad) between the mid-gut and the cephalic border of the body these branches pass to the compound eye, which lies near the dorsal surface of the body. Indeed, this median eye lies against the shell, vertically above the supra-oesopahgeal ganglion [fig. 2, 9, 10 *o*, 42 *o*].

In *Notodromas*, according to Wenzel Vávra, there are three optic nerves arising from the apex of the brain [fig. 30]. Here also we find that the three parts of the eye are widely separated [fig. 30]. It does not require a very active imagination to conclude that simultaneously with the divarication of the component parts of the triune eye there went a longitudinal tripartite splitting of the entire optic nerve.

Antennulary Nerves.—The paired antennulary nerves arise one from near each lateral surface of the apex of the supra-oesophageal ganglion [fig. 10, 42]. After leaving this ganglion the nerve passes in a caudally convex curve upwards (dorsad), between the mid-gut and the cephalic border of the body, to the corresponding ganglion. There is no root ganglion at the base of this nerve.

Antennary Nerves.—Where each circum-oesophageal commissure leaves the supra-oesophageal ganglion arises an antennary nerve [fig. 3]. This nerve receives its fibres, not only from the brain, but also from a ganglion that extends in a straggling manner along the pharyngeal collar [fig. 2, 8].

Labial Nerves.—The labial nerve or nerve of the upper lip arises in the cephalic portion of the sub-oesophageal ganglion. Instead of leaving the central nerve chain immediately, this nerve passes upwards (cephalo-dorsad) into the pharyngeal collar and thence forward (cephalad) to the upper lip [fig. 3, 16, 42]. There is a large root ganglion at the origin of this nerve [fig. 3]. The labial nerve has two main branches. One branch innervates a pear-shaped sense organ situated in the front part of the body below [ventrad of] the base of the antenna, while the other innervates a harp-shaped sense organ located in the lower [ventral] portion of the upper lip [fig. 16].

Mandibular Nerves.—From each lateral portion of the sub-oesophageal ganglion, just below (ventro-caudad of) the place of fusion of the pharyngeal collar with this ganglion, a mandibular nerve leaves the nervous chain. Just after entering the mandible this nerve branches, one branch passing upwards (cephalo-dorsad) to the mandibular muscles, while the other passes downward (cephalo-ventrad) to a sense organ at the base of the mandibular teeth [fig. 7 *mx*, 40 *md*]. There is no root ganglion to this nerve.

Labral Nerves.—From each lateral portion of the ventral aspect of this same ganglion, a short distance behind (caudad of) the origin of the mandibular nerve, arises a labral nerve. Thence the nerve passes, in a caudally convex curve, downward (ventrad) to the lower lips [fig. 32, 42]. The chief function of this nerve is to innervate a harp-shaped sense organ located in the lower lip [fig. 16 *D*]. This nerve has a root ganglion.

First Maxillary Nerves.—A short distance caudad of the origin of the mandibular nerve, a maxillary nerve leaves each side of this same ganglion. This is the first maxillary nerve. It passes latero-caudad to the first maxilla [fig. 7 mx^2, 42].

Thoracic Nerves.—All of the four pairs of nerves just described arise from the ventral side of the sub-oesophageal ganglion. We now come to a pair of nerves that arise from the dorsal aspect of the same ganglion. These are what I beg permission to call the thoracic nerves. These nerves arise from the lateral portion of the dorsal aspect of this ganglion just back of (caudad of) the origin of the first maxillary nerve. Arising as it does from the dorsal aspect of the ventral chain, the root of this nerve lies immediately beneath the endoskeleton. This nerve passes obliquely upwards and backwards (dorso-latero-caudad), and, after branching, innervates the abductor muscles of the shell [fig. 32 *T*, 42 *T*].

To the best of the writer's knowlege, neither this nerve nor the labial nor the labral nerves have been described by any previous writer on the *Ostracoda*.

From the cephalic extremity of the ventral nerve chain to the roots of the thoracic nerve the nerve cells are confined to the ventral and ventro-lateral surfaces of the cord. Behind (caudad of) the roots the nerve cells entirely surround the ganglia and occupy the mesal plane as well.

Within the ventral chain, beneath the origin of the thoracic nerves, there is a pair of ellipsoidal cavities. These might properly be called thoracic ventricles.

Second Maxillary Nerves.—This nerve arises from the lateral aspect of the first ganglion behind (caudad of) the suboesophageal ganglion.

Leg Nerves.—From the last ventral ganglion of *Cypris* arise two paired nerves and one unpaired nerve. The paired nerves innervate the legs, while the unpaired nerve passes into the abdomen. The nerve of the first leg passes immediately latero-ventrad to the first leg; but the nerve of the second leg passes backwards (caudad) along with the abdominal nerve, a short distance before passing to the second leg [fig. 42].

Abdominal Nerve.—As has been stated, from the caudal portion of the last ventral ganglion a large unpaired median nerve passes upwards and backward (dorso-caudad) into the abdomen. This is the abdominal nerve. After entering the abdomen, this nerve becomes more and more attenuated, owing to the fact that it gives off fibres to the reproductive system [fig. 32 *an*, 42 *Ab*].

The above descriptions of the principal nerves of *Cypris* do not agree either with the descriptions of the few men who have written on this subjects or with the statements made in my preliminary paper. I cannot answer for the other men, but my error was in mistaking the labial nerve for the mandibular nerve. If you but recall the compactness of the anterior (cephalic) region of the body of *Cypris*, you can see how easy it would be to make such a mistake. However, I now have at hand several series which demonstrate, beyond the shadow of a doubt, that the nerves arise as stated in this paper.

No doubt it is this same compactness of the cephalic portion of the body of *Cypris* which is responsible for the non-discovery of the labial, labral, and thoracic nerves by other observers.

Careful search has not yet revealed a sympathetic nervous system.

Sense Organs.

Compound Eye.—The most conspicuous sense organ of the genus *Cypris* is the compound eye. When viewed from above, this eye usually resembles a quadrilateral pigment spot [fig. 36]. In *Cyclocypris* and *Cypria*, this eye is quite large and the pigment is intensely black; in *Cypris* and *Cyprinotus*, the eye is of medium size; in *Candona*, the eye is inconspicuous and the pigment is reddish; while in *Typhlocypris*, according to Wenzel Vávra, there is no eye in the adult. The eye of the embryonic *Typhlocypris*, according to the same author, becomes metamorphosed into an inconspicuous non-optical sense organ.

This eye is a triune structure. It consists of a median and two lateral portions, each of which is supplied with a lens [fig. 2]. The lens of the median portion is on the front aspect [fig. 36], while the lenses of the lateral portions are on the sides [fig. 2, 36]. This median compound eye, which lies in about the same vertical transverse plane as the supra-oesophageal ganglion, is located where the dorsal border of the animal is united to the dorsal portion of the shell. Hence there are two planes, at right angles to each other, that pass through both the compound eye and the supra-oesophageal ganglion. These two planes are the mesal and a transverse plane.

Histologically there are five parts to this compound eye: lens, retina, pigment, superficial epithelium, nerve [fig. 2]. Corresponding to each of the three divisions of the eye we have a retina and a lens [fig. 2] and a nerve. The pigment is deposited between and around the retina. The retinas are cellular structures, the cells being arranged with their longest axis perpendicular to the outer surface of the retina [fig. 2]. Each retina is supplied with a lens, and these are always on the outer surface. In the lateral portions these lenses are on the side, while in the median the lens is on the front aspect [fig. 36]. The median portion lies lower than the lateral. Excepting the central portions of the lenses, all of the surface of the eye, as well as the space between the retinas, is pigmented [fig. 2, 36].

In *Cypris herricki* Turner the nerve fibres are united to the outer (peripheral) ends of the retinal cells. This agrees with what Dr. Claus found to be the state of things in the eyes of the *Copepoda*, *Clodocera* and *Ostracoda* examined by him [7].

There is a striking resemblance between the triune eyes of the *Ostracoda* and those of the *Copepoda*. In describing the compound eye of *Calanella mediterranea*, Dr. Grenacher remarks "Each eye is composed of a pigment cup and a strongly refractive transparent 'lens' laid in and on it. The term lens is, however, not applicable. It is composed of several cells, each of which is connected, whether at its outer or inner side is not yet certain, with a fibre of the optic nerve, and must therefore be considered as a retinal cell." Since the superficial resemblance between the *Ostracod* eye and the *Copepod* eye is so great, one is apt to conclude that the above words of Dr. Grenacher might be applied to the *Ostracod* eye. Against such an assumption I desire to enter a most emphatic protest. As stated above, in the eye of *Cypris* we find both retinal cells and lenses, and the two structures are histologically quite distinct. On the outside of the eye, covering lens and all, there is a nucleated epithelial layer [fig. 2].

Since the publication of the paper[1] in which O. Bütschli attempts to show how the lateral eyes of the vertebrates may have been derived from the median tripartite eye of *Salpa*, this tripartite eye, which is of almost universal occurrence among the entomostraca, becomes enhanced in interest. One at once begins to speculate on the possibility of this median triune eye of the entomostraca becoming transformed into the lateral eyes of the higher crustacea. Indeed, in his late work, Dr. Claus[2] has already stated that the lateral eyes of the Corycæidæ are laterally rotated portions of the median eyes. In this connection it may be of interest to quote a portion of Dr. Giesbeck's

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[1] Einige Bemerkungen ueber die Augen der Salpen, *Zool. Anz.*, XV., Jahrg. 349.

[2] Ueber die feineren Bau des Medianauges der Crustaceen. *Anzeiger Akad. Wien*. 1891, pp. 124-127. Ref. in *Zool. Jahrsbericht* für 1891, Arthropoda, 29.

résumé of Dr. Claus' paper: "Die Sietenaugen der Corycæiden sind abgedrückte Theile des Medienauges, diejenigen der Pontelliden entsprechen dagegen dem zusammengesetzten Arthropodenauge, während ihr ventrales Auge ein dreitheliges Medienauge dürfte ebenso wie die beiden frontalen Sinnesorgane der ersten anlage nach auf Zellengruppen der Scheitelplatte, vor der aus wir, . . die obern Schlundganglien der Gliederthiere abzuleiten haben, zu beziehen sein; die drei Augentheile sind vielleicht mit den drei Punktaugen an der Scheitenplatte von Annelidenlarven phylogenetisch in Beziehung zu bringen; die Lage ihrer Pigmentzellen und ihre inverse Form werden auf eine convergent nach einem Punkte gerichtete Drehung zurückgeführt, welche mit dem Herabrücken des Organs in die Tiefe verbunden war; die Secret und Cornealinsen werden von Hypodermiszellen abgeschieden, ähnlich wie Krystallkegel und Corneafacette des zusammengesetzen auges; das auge besitzt eine mesodermal Hülle, die sich in das neurilemm des Opticus fortsetzt; Die function des Medienauges war ursprünlich das Thier bezüglich der Richtung der Lichtquelle zu orientiren; bei compliciterem Bau, schon bei den Calaniden, hat es wahrscheinlich auch die Fähigkeit einer beschränkten Bildperception. Am Medianauge der Malakostraken-larven ist der ventral Becher bisher incht beobdachtet, aber wohl auch vorhanden."

A comparative study of the eyes of the *Ostracoda* lends support to the view held by Dr. Claus. In *Typhlocypris* there is practically no eye, in *Candona* the triune eye is small and inconspicuous, in *Cypris* it is somewhat larger, in *Cypria* and *Cyclocypris* it is large and conspicuous, while in *Notodromas* the paired portions of the compound eyes are so far separated that they look like a pair of simple eyes united to a median eye by means of a stalk [fig. 30].

Pear-shaped Sense Organs.—In the cephalic portion of the body, a short distance above (dorsad of) the upper lip, there is a pair of peculiar pear-shaped sense organs [fig. 16, *P*]. To the best of my knowledge this organ has been overlooked by all other writers on the histology of *Cypris.* When viewed from the side, this is a pear-shaped organ, with its base directed outwards (ectad) and its apex inwards (entad).

In hæmatoxylin preparations, in the base of this pear-shaped organ, there is a densely stained circular disc. In *Cyprinotus incongruens* (Ramdohr) this disc is 12.92 micromillimeters in diameter [fig. 34].

The apex of this organ is surrounded by a ganglion of nerve cells [fig. 34].

The length of this organ varies in different species. In a general way, the larger the species the larger this sense organ. In *Cyprinotus incongruens* Ramdohr, which is about 1.35 millimeters in length, this organ is 35.53 micromillimeters long and 32.3 micromillimeters wide; while in *Cypris herricki* Turner, which is about three millimeters in length, this organ is 71.06 micromillimeters long and 48.45 micromillimeters wide. In other words, in *Cypris herricki*, which is about twice as long as *Cyprinotus incongruens*, the pear-shaped sense organ is about twice as long as the corresponding organ of *Cyprinotus incongruens.*

This organ is situated a short distance below the base of the antenna and close to the outer wall of the body. The broad base lies in contact with the body wall [fig. 16, *P*].

Since this organ is much larger in *Cypris herricki* Turner than in any other form known to me, the following histological study of the organ is based upon sections of that species.

From a histological standpoint, this pear-shaped organ is composed of a neuroglia-like matrix, in which are two transverse rows of nuclei. One of these rows of large nuclei is located about half way between the base and the apex, while the other row is situated near the apex. Near the base of this organ the matrix is denser than it is elsewhere [fig. 31]. The organ is surrounded by a nucleated epithelium.

This organ is innervated by a branch of the labial nerve [fig. 16].

There is a pair of these organs, but they are so closely approximated that a hasty glance might not reveal both members of the pair.

As to the function of this organ, I have no definite proof; but I am inclined to think that it functions as an eye. In *Cypridina*, besides the usual compound eye, Dr. Claus has described a median, unpaired simple eye. Now I am inclined to think that this pear-shaped organ of *Cypris* is homologous with the unpaired simple eye of *Cypridina*. At first blush, there are two facts that seem to militate against such an assumption 1st, the median eye described by Claus is unpaired, while this pear-shaped organ is distinctly paired; 2nd, the median eye described by Dr. Claus is near to the compound eye, while this pear-shaped organ is far removed from the compound eye. In spite of these opposing facts, there are several weighty considerations which lead me to hold to the statements made above. 1st, *Cypridina* is much less *compact* than *Cypris*; 2nd, in *Cypridina* the compound eye and the simple eye are situated near the centre of the shell; 3rd, in *Cypridina* the parts of the compound eye are widely separated, while in *Cypris* they are closely approximated. May it not be that in the ancestors of *Cypris* the compound and simple eyes lie near each other and near the middle of the shell, as it now is in *Cypridina?* May it not be that when the compound eye migrated towards the dorsal surface, the simple eye migrated towards the ventral? And when we remember that in histology this pear-shaped organ resembles the invertebrate simple eye, we have, I think, sufficient grounds for calling this a simple eye. To be sure this pear-shaped organ is one of a pair while the simple eye of *Cypridina* is unpaired; but in this day, the phenomena of transformations due to fission and to fusion are too well known for this difference to merit even a passing consideration. The settlement of this question, however, must be left to embryology.

Sense Organs of the Mouth.—In this same region of the body, there is another set of hitherto undescribed sense organs. From the caudal border of the upper lip, from the cephalic border of the lower lip, and from between the teeth of the mandible, arise numerous hairs [fig. 16]. These hairs are sometimes plumose [fig. 35]. At the base of each of these sets of hairs there is a similar sense organ [fig. 16, *B*, *C*, *D*]. Each of these organs is composed of oblong nucleated cells, which are arranged with their longest axes perpendicular to the hirsute surface [fig. 4]. The organs in the upper lip are innervated by a branch of the labial nerve, those in the mandible by a branch of the mandibular nerve and those in the lower lip, by the labral nerve [fig. 16]. Thus we have, surrounding the mouth, three pairs of similar sense organs.

I have no definite proof as to the function of this set of organs; but, since they surround the mouth, they probably function as food discriminators. Whether this discriminating sense is one of touch or taste I am not prepared to state.

Auditory Organ.—After describing rather minutely what he considers to be a sense organ located at the tip of the second foot, Dr. Rehberg expresses his belief that that organ is an ear. Now I agree with Dr. Rehberg in believing that there is a sense organ located in the tip of the second foot; but I think that its function is not auditory but tactile. I do not think that the structure of the tip of the second foot warrants Dr. Rehberg's assumption. And beside, at the base each of the antennules I have found what I consider the auditory organ of *Cypris* [fig. 16, *E*]. This is an ellipsoidal body in the centre of which there is a sac. The space between the outer wall of the ellipsoid and the sac is occupied by a single layer of columnar cells. The nuclei of these cells are located near the periphery. These cells are best seen in transverse sections of the organ [fig. 33]. Often the cells contain large vacuoles [fig. 29]. Within the sac there is a small spherical body which I take to be an otolith [fig. 29]. Since in most of my preparations this sac has been filled with a deposit of the stain used [fig. 33] I am not sure that this spherical body that I find in other preparations is an otolith or merely a bit of stain.

As to the innervation of this organ, I have no definite knowledge. However, the antennary nerve is so intimately associated with this organ [fig. 29*a*], that I am inclined to believe that that nerve innervates the auditory organ.

There are two patent facts that lead me to hold that this is an auditory organ: 1st, in histology it resembles an otocyst;

2nd, in location it resembles the auditory organ of the higher crustacea (*Malacostraca*).

Olfactory Organs.—On the third joint of the antenna of all the fresh-water *Ostracoda*, there exists a peculiar seta which all writers have called an olfactory organ. As has been remarked by other writers on this subject, this organ consists of the following three segments: basal piece, middle piece, end piece [fig. 15]. In some cases the basal piece has been subdivided into two pieces [fig. 17], while in others no middle piece can be distinguished [fig. 14]. The nerve enters this organ through a perforation in its base. Thence it extends along the axis of this portion until it reaches the base of the middle-piece, where it terminates in a small knob [fig. 15, 17]. In *Cypris herricki* Turner this terminal knob is about three micromillimeters in diameter.

The usual width of this organ is about three micro-millimeters. However, in *Cypria exculpta* Fischer it is only about two micromillimeters wide, while in *Cypris herricki* Turner it is about eight eight micromillimeters wide. In length the organ varies from about 85 micromillimeters in *Cypris herricki* Turner to about 29 micromillimeters in *Cypria inequivalva* Turner. In the same genera the length of the organ varies directly with the length of the body of the specimen—the longer the body the longer the organ. In those genera in which the swiming setae of the antenna are greatly developed (*Cyclocypris*, *Cypria*) this olfactory organ is relatively larger than in those genera in which the natatory setæ of the antenna are more feebly developed (*Cypris*, *Candona*).

In the same species the tip of this organ may be either blunt or pointed. Indeed, on one antenna of a specimen the apex of this organ may be blunt, while on the other the tip may be pointed.

The shape of this organ varies in different species. A consultation of figures 12-15, 17-19 and 21-22 will give a better idea of these various shapes than could any number of words.

The following table has been compiled in order to facilitate a comparative study of this olfactory organ:

Table showing the relative size of Leydig's organ in a few Cypridæ.	Basal Piece....	Middle Piece..	End Piece.....	Total length of Leydig's organ	Length of Specimen ....
NAME OF SPECIMEN.	MICROMILLIMETERS				
Candona acuminata (Fischer) ♀	13	10	20	43	1250
Candona crogmani Turner ♀, type	19	6	23	48	1520
“ “ “ exception	16	—	19	35	
“ “ “ ♂	13	6	26	45	1520
Candona delawarensis Turner, ♀	10	3	23	36	950
“ “ “ ♂	14	5	20	39	
Candona fabæformis (Fischer) ♀	12	6	19	37	1030
Cyclocypris lævis (O. F. Müller)	29	6	32	67	570
Cypria exculpta (Fischer)	23	3	16	42	640
Cypria inequivalva Turner, ♀	13	10	6	29	520
Cypria ophthalmica (Jurine)	10	10	16	36	580
Cypridopsis vidua (O. F. Müller)	19	—	16	35	700
Cyprinotus burlingtonensis, Turner, ♀	26	10	29	65	1600
Cyprinotus crena, Turner, ♀	19	8	23	40	1230
Cyprinotus incongruens (Ramdohr)	39	6	16	61	1350
Cypris fuscata (Fischer)	36	7	20	63	1500
Cypris herricki Turner ♀	32	4	49	85	3000

Sensory Setæ.—In addition to the sense organs already described there are several types of sensory setæ that deserve at least a passing notice. Not having been able to trace a nerve into any of these setæ, I have given but a brief notice of them.

At the tip of the antennules and antennae of all the *Cypridæ* there occurs a two-segmented sensory seta [fig. 20]. This seta is longest in *Taphlocypris*, where it is as long as the terminal claw. In *Condona fabæformis* Fischer this seta is 48 micromillimeters long. In this case, the terminal segment is ten micromillimeters long. Owing to its small size and to the number and size of the associated claws and filaments, this organ is a very difficult object to study.

At the extremity of the fourth segment of the antenna of *Notodromas* there is a peculiar seta with a funnel-shaped tip [fig. 28].

At the tip of the fourth segment of the antenna of the male members of the genera *Candona*, *Candonopsis* and *Cypris* there is a peculiar two-jointed seta [fig. 24-27]. Dr. Wenzel Vávra considers this a rudimentary organ. Its morphology varies in different species. By Dr. Wenzel Vávra the variations that we meet with in this organ are considered to be of taxonomic value.

On the tip of the third and fourth segments of the mandibular palp of certain *Cypridæ*, there occurs a short dagger-shaped setose seta [fig. 23 *D.S.*]. This seta was first described in the "Entomostraca of Minnesota."[1] This seta occurs in: *Candona crogmani* Turner, *Candona delawarensis* Turner, *Cypridopsis vidua* O. F. Müller, *Cypris herricki* Turner, *Cyprinotus burlingtonensis* Turner.

Recapitulation.

1. The nervous system of *Cypris* consists of a supra-oesophageal ganglion, which is connected to a ventral chain by a pharyngeal collar.

2. The ventral chain consists of an infra-oesophageal and two subsequent ganglia. The infra-oesophageal ganglion has probably been compounded out of at least three pairs of ganglia.

3. From the supra-oesophageal ganglion arise one unpaired and two paired nerves. These nerves are: the optic, the antennulary, the antennary. The antennary nerve receives a portion of its fibres from a ganglion that lies within the pharyngeal collar. The nerve itself arises from the point where the collar joins the supra-oesophageal ganglion.

4. From the infra-oesophageal ganglion arise five pairs of nerves. Four of these pairs arise from the ventral portion of the ganglion, while the other arises from the dorsal. The four that arise from the ventral half are: the labial, the mandibular, the labral, and the first maxillary. The one that arises from the dorsal portion is the thoracic nerve.

5. The labial nerve passes forward into the pharyngeal collar before leaving the central nerve chain.

6. The thoracic nerve innervates the shell muscles.

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[1] C. L. Herrick and C. H. Turner. Synopsis of the Entomostraca of Minnesota with descriptions of related species comprising all known forms from the United States included in the orders Copepoda, Cladocera, Ostracoda. *St. Paul, Minn.*, 1895.

7. The 2nd maxillary nerve arises from the first ganglion back of the infra-oesophageal ganglion.

8. From the last thoracic ganglion arise one unpaired and two paired nerves. The paired nerves are the leg nerves; the unpaired nerve is the abdominal nerve. The abdominal nerve innervates the genital apparatus.

9. There is a median compound triune eye. The eye is situated near the dorsal surface. Each of the three divisions of this eye is supplied with retinal cells and a lens. The nerve enters the outer ends of the retinal cells. In most of the fresh-water *Cypridæ* the component parts of this eye are closely approximated. In *Notodromas*, on the contrary, the three parts are widely separated.

10. In most of the fresh-water *Cypridæ* the optic nerve is a median unpaired structure, which splits into three branches. In *Notodromas*, however, there are three distinct optic nerves.

11. In the front part of the body, between the base of the antennae and the upper lip, there is a pair of pear-shaped sensory organs. These are probably simple eyes. This organ is innervated by a branch of the labial nerve.

12. At the base of the antennule there is an auditory organ.

13. Bordering the mouth there are three pairs of similar sense organs. These organs lie in the upper lip, at the base of the mandibular teeth, and in the lower lip. They are innervated by branches of the following nerves: labial, mandibular, and labral.

14. On the third segment of the second antenna there is the so-called olfactory organ. This organ consists of three segments; the basal, the middle, and the end piece. The nerve enters the basal portion and extends to the base of the middle piece, where it terminates in a knob-like swelling.

15. In addition to the above sense organs there are several types of sensory setae.

EXPLANATION OF PLATES.

Excepting where otherwise stated, the plates were all made from camera drawings made by the writer.

PLATE III.

Fig. 1. *Cypris herricki* Turner, transverse section of body in the region of the posterior portion of the mid-gut. A, endoskeleton; n, nerve chain.

Fig. 2. *Do.*, *do.*, transverse section of median eye.

Fig. 3. *Do.*, *do.*, longitudinal section of circum-oesophageal commissure. a^2, antennary nerve; md, mandibular nerve.

Fig. 4. *Do.*, *do.*, transverse section of the sense organ of lower lip.

Fig. 5. Transverse section of the endoskeleton.

Fig. 6. *Do.*, *do.*, transverse section of the body in the region of the lateral diverticles of the mid-gut.

PLATE IV.

Fig. 7. *Cypris herricki* Turner, longitudinal section through the sub-oesophageal ganglion. Mx′, mandibular nerve; mx″, 1st maxillary nerve.

Fig. 8. *Do.*, *do.*, longitudinal section through the brain at the level of the origin of the circum-oesophageal commissures. A^2, antennary nerve.

Fig. 9. *Do.*, *do.*, median longitudinal section of the entire body. S.g., brain; A, harp-shaped sense organ of the lower lip; B, ventral nerve chain; C, cells in wall of oesophagus.

Fig. 10. *Do.*, *do.*, transverse section through the brain, in the region of the optic and antennulary nerves.

Fig. 11. *Do.*, *do.*, longitudinal section of a portion of the ventral chain.

PLATE V.

Fig. 12. *Candona delawarensis* Turner, olfactory seta from the third joint of the antenna.

Fig. 13. *Candona faœbformis* (Fischer), do., do.

Fig. 14. *Cypridopsis vidua* (O. F. Müller), do., do.

Fig. 15. *Cypris herricki*, Turner, do., do.

Fig. 16. *Cypris herricki* Turner, longitudinal section through the body. A.N., antennulary nerve; B, harp-shaped sense organ of the upper lip; C, harp-shaped sense organ at the base of the mandibular teeth; D, harp-shaped sense organ in the lower lip; E, auditory organ; L.N., labial nerve; P, pear-shaped sense organ of the upper lip; S.G., supra-oesophageal ganglion.

Fig. 17. *Cypris fuscata* Jurine, olfactory seta from the third joint of the antenna.

Fig. 18. *Cyclocypris laevis* (O. F. Müller), do.

Fig. 19. *Cypria exculpta* (Fischer), do.

Fig. 20. *Candona fabœformis* (Fischer), sensory seta from tip of first antenna.

Fig. 21. *Cypria ophthalmica* (Jurine), sensory seta from third joint of antenna.

Fig. 22. *Cyclocypris laevis* (O. F. Müller), do., do.

PLATE VI.

Fig. 23. *Cypris herricki* Turner, mandibular palp. D.S., dagger-shaped seta.

Fig. 24. *Candonopsis pubescens*, sensory seta from the four segments of the antenna of the male.

Fig. 25. *Condonopsis kingslei*, do.

Fig. 26. *Candona fabæformis*, do.

Fig. 27. *Candona candida*, do.

Fig. 28. *Notodromas monacha*, Sensory seta from the fifth segment of the antenna.

Figures 24-28 have been copied from Wenzel Vávra.

PLATE VII.

Fig. 29. *Cypris herricki* Turner, auditory organ from a longitudinal perpendicular section. A. antennulary nerve; m, muscle.

Fig. 30. *Natodromas monacha*, eyes (after Vávra).

Fig. 31. *Cypris herricki* Turner, pear-shaped organ of the upper lip, sectional view.

Fig. 32. *Cyprinotus incongruens* (Ramdohr), ventral chain. A, antennary nerve; A N, abdominal nerve; L, labial nerve; L′, branch of same to pear–shaped organ; L″, branch of same to harp-shaped organ; La, labrum.

Fig. 33. *Cypris herricki*, Turner, auditory organ, from a horizontal-longitudinal section.

Fig. 34. *Cyprinotus incongruens* (Ramdohr), pear-shaped sense organ of upper lip, surface view.

Fig. 35. *Cypris herricki* Turner, tip of mandible showing hairs that belong to the sensory organ found in the mandible.

Fig. 36. *Cypris pubera*, eye, surface view (after Wenzel Vávra).

PLATE VIII.

Fig. 37. *Cypris herricki*, Turner, wall of mid-gut.

Fig. 38. *Cypris herricki*, Turner, tip of second foot.

Fig. 39. *Do.*, *do.*,wall of oesophagus.

Fig. 40. *Cyprinotus incongruens* (Ramdohr), transverse section through the mandibular nerve. S, sub-oesophageal ganglion; md, mandibular nerve.

Fig. 41. *Cypris herricki* Turner, surface view of wall of mid-gut.

Fig. 42. Diagram of the central nervous system of *Cypris*. A, atennulary nerve; Ab, abdominal nerve; At, antennary nerve; L, labial nerve; L′, branch of labial nerve passing to the pear-shaped sense organ; L″, branch of labial nerve passing to the harp-shaped sense organ; Lb, labral nerve; Lg′, 1st leg nerve; Lg″, second leg nerve; Md, mandibular nerve; Mx′, 1st maxillary nerve; Mx″, second maxillary nerve; T, thoracic nerve; T. V., thoracic ventricle.

Fig. 43. Nerve cell of *Cypris*.

PRELIMINARY NOTES ON THE CRANIAL NERVES OF CRYPTOBRANCHUS ALLEGHANIENSIS.

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The present communication is by no means a complete description of the cranial nerves of Cryptobranchus, but is merely a somewhat cursory sketch of the distribution of most of the more important rami. It was the hope of the writer to have completed before this time a study of the brain and cranial nerves of this amphibian, working out the nerve components from serial sections, but the difficulty in obtaining embryonic material for sectioning has so delayed the work that it has been thought best to present a brief preliminary account based almost entirely upon dissections of adult animals.

Recent researches on cranial nerve components render it possible to determine, even by dissection, some points of importance in nerve homologies, though, of course, reconstruction from sections will be necessary to ascertain the more intimate relations of the components.

In general, no attempt has been made in the present paper to trace the relations between nerve-roots and the ultimate rami. So far as possible the writer has endeavored to indicate homologies with other amphibians, basing the comparisons mainly upon recent investigations on Rana, Amblystoma and Salamandra.

Nervus olfactorius.—This nerve is somewhat peculiar in Cryptobranchus from the fact that it divides into numerous branches before leaving the cranial cavity. Within the cranium these branches extend cephalad in two large bundles on each side, giving each olfactory nerve the appearance of being double.

Nervus opticus.—The optic is very similar to that of urodeles in general. There is a slight vestige of a lumen at the base of the nerve.

The nerves of the eye-muscles are all present but very small. The *oculomotor* is the largest of the three and maintains an independent course throughout its whole extent, leaving the cranium by a special foramen slightly caudad of the optic foramen. In part of its course this nerve lies very close to *ramus ophthalmicus profundus* of the fifth. The courses of the *trochlearis* and *abducens* have not been determined. They are both extremely minute, as would be supposed from the very degenerate condition of the eye-muscles. The point of origin of the *abducens* appears to be somewhat variable. It has been figured by Osborn as leaving the medulla on a level with the fifth nerve, but transverse sections prepared by the writer show the *abducens* taking its exit on a level with the cephalic roots of the glossopharyngeo-vagus complex as it does in Rana, Diemctylus, Salamandra, Amblystoma and other forms.

Nervus trigeminus.—The distribution of the fifth nerve in Cryptobranchus has been described by Fischer and more recently by H. H. Wilder, though neither of these writers has given a complete description. The first ramus, the *r. ophthalmicus profundus*, after leaving the ganglion, traverses a canal in the pterygoid bone, coming to the surface some distance cephalad of the other two rami. It trends cephalad, passing mesad of the eye-ball and dorsad of the optic nerve and all the eye muscles except the superior oblique and superior rectus. The greater part of the ramus passes cephalad to a point cephalad of the eye, where it breaks up into numerous branches anastomosing with branches of the superior maxillary ramus. The nerve thus formed enters a groove in the superior maxillary bone and sends branches to the skin of the upper lip through three or four foramina and a small notch in the lateral border of the anterior nares. This branch has been called by Wilder *ramus nasalis externus.*

The two branches to the nasal capsule have been well described by Wilder who designates the ventral and dorsal branches respectively as *ramus nasalis externus I* and *ramus nasalis externus II.* The former, as shown by Wilder, receives a branch from the *ramus maxillaris V.*

In addition to the branches already described there is a small branch entering the eye-ball which is probably to be regarded as the ciliary nerve, and another small branch which is traceable to the region of the antorbital fissure in the nasal capsule. The latter branch is probably distributed to the glands of the nasal region, but a study of serial sections will be necessary to settle this point.

The *ramus maxillaris superioris* of the Trigeminus breaks up into several branches immediately upon leaving the cranium. It runs dorsad of the masseter muscle then dips ventrad of the eye supplying numerous branches to the skin of the upper lip and anatomosing with the ramus nasalis externus of the deep ophthalmic. A branch also runs along the floor of the nasal capsule as described in connection with the *ramus ophthalmicus profundus.* The *ramus maxillaris superioris* is accompanied for some distance by the ramus ophthalmicus superficialis of the facial nerve, and the two are described together by Herrick in Amblystoma as *ramus fronto-maxillaris.* Though the two nerves run close together for a part of their course, they are separate as far back as the ganglion Gasseri. It is almost certain that one of the branches which appears to belong to the superior maxillary ramus represents the ramus buccalis VII (in the sense in which this name is used by Strong and the writers on fishes). This view is supported by the presence of well-developed lateral line organs between the eye and the angle of the mouth, the so-called infra-orbital sense organs.

The *ramus mandibularis V* is larger than either of the other two rami. At its point of exit from the skull it gives a small branch to m. temporalis, then, trending laterad, it pierces m. masseter to which it contributes several twigs. At about the middle of its course through m. masseter a fairly stout branch separates from the main ramus and runs latero-caudad passing through a slight notch under the lateral border of the squamosal bone. This branch sends a number of twigs cephalad, supplying the skin covering m. masseter and the region of the angle of the jaw; it is evidently a general cutaneous branch and may represent Strong's *ramus accessorius V*. The greater part of *ramus mandibularis V* enters the inferior maxillary by a large foramen about one-third the length of the bone from the proximal end. Just before its entrance into the mandible it divides into two branches, the caudal of which passes directly through the mandible, appearing on the ventral border almost opposite the point of entrance. The foramen of exit is included between the splenial and angular bones. This portion of the nerve innervates m. mylohyoideus anterior, and is traceable almost to the symphysis menti, breaking up into several branches on the ventral surface of the muscle. C. J. Herrick finds this branch to contain sensory fibres in Amblystoma, and the same is probably true in the case of Cryptobranchus. The branch in question is called *ramus mentalis* by von Plessen and Rabinovicz, but, as Herrick states, the name is more properly applied to the ramus we shall next describe.

The *ramus mentalis V* is the cephalic one of the two branches which enter the mandible. It divides almost immediately into two branches which are separated by the Meckelian cartilage; the ental branch is the dental nerve and supples the alveolar region; the other, a larger branch, lies ectad of the Meckelian cartilege and traverses a canal in the dentary bone. Shortly beyond its point of separation from the inner branch it is joined by the ramus alveolaris VII, which enters a foramen in the ectal surface of the dentary bone. The fibres of the two nerves mingle and pass cephalad through the canal above mentioned, extending almost to the symphysis menti and giving off some half-dozen clusters of small branches which pierce the ectal surface of the dentary bone at intervals and supply the skin of that region. It is not certain as yet whether these fibres to the skin belong to the ramus mentalis V or to the ramus alveolaris VII.

Nervus Facialis.—The seventh nerve of Cryptobranchus does not exhibit any very important variations from the condition generally found in urodeles. In correlation to the well-marked lateral line sense-organs, we find the rami of the dorsal VII root, or VIIb. of Strong, well developed. The fibres of the *Rr. ophthalmicus superficialis* and *buccalis* are very probably, judging from analogy with the frog larva, contained in a large root (VII *u* and *l* of Osborn) which enters the caudal border of the Gasserian ganglion. These two rami leave the ganglion in company with *ramus maxillaris superioris* passing with it dorsad of *m. temporalis*. *Ramus ophthalmicus superficialis VII* runs cephalad to the nostril, innervating the supra-orbital sense-organs of the lateral line system. This ramus seems to have been entirely overlooked by Fischer, and several recent writers have called it *ramus frontalis V*. Its community of origin with other lateral line rami, as shown by Strong, and its distribution to the region of the supra-orbital line of sense-organs leaves no doubt as to its true nature. *Ramus buccalis VII* accompanies *ramus maxillaris superioris V* as far as the eye and ends in the infra-orbital sense-organs. This is not the homologue of the *ramus buccalis* as described by von Plessen and Rabinovicz and by C. J. Herrick, but the *ramus maxillaris V* of these writers no doubt includes the *ramus buccalis* as the name is here used. The root marked *d* in the figures of Salamandra given by von Plessen and Rabinovicz and of Amblystoma by Herrick is probably homologous with the VII *u* and *l* of Crytobranchus as figured by Osborn and probably contains the fibres of the two lateral line rami here described.

Besides the two rami of the VII already described there are four others, all of which were described by Fischer, who called them *Rr. palatinus*, *mentalis*, *alveolaris* and *jugularis*. *Ramus palatinus* is rather small; it passes ventrad through a foramen in the proötic ossification and is covered ventrally for some distance by the very broad parasphenoid bone. Near the level of the posterior nares it forms anastomoses with Rr. ophthalmicus profundus V and maxillaris superioris V. On account of its anastomoses the ultimate distribution of the facialis fibres can be determined only by serial sections through the head. The *ramus alveolaris* of Fischer runs laterad along the dorsal surface of the squamosal bone, then cephalad between m. masseter and the skin, and enters a foramen in the lateral aspect of the dentary bone cephalad of the area of insertion of m, masseter. Within the bone it unites with a branch of ramus mentalis V, and pursues its course almost to the symphysis menti, supplying branches to the lower lip, through some six or eight foramina in the dentary bone. As stated in connection with ramus mentalis V, it is not certain which component supplies the fibres to the skin of the lower lip. It appears to me not improbable that this ramus alveolaris VII may correspond to the *ramus mandibularis internus VII* described by Strong in the tadpole, and may therefore represent the *chorda tympani.* The dentary being a dermal bone, the nerve may have secondarily become covered by it. I have not been able to find all the branches described by von Plessen and Rabinovicz and by Herrick in Salamandra and Amblystoma respectively. The ramus in question must be represented by the alveolaris, accessory hyo-mandibularis or buccalis of Salamandra and Amblystoma, in the sense in which Herrick and v. Plessen and Rabinovicz use these names. Herrick thinks, perhaps with good reason, that the hyo-mandibular ramus of Amblystoma is the homologue of Strong's chorda tympani or ramus mandibularis internus. If my supposition regarding the homologies is correct, the latter name is preferable to *ramus alveolaris.* Fischer's *ramus mentalis* is really the lateral line ramus to the lower jaw and therefore the branch which Strong designates as *ramus mandibularis externus* in the tadpole. In Cryptobranchus this branch does not accompany the hyo-mandibular as in the frog, but is a separate ramus as far back as the ganglion. It courses laterad along the dorsal face of the squamosal bone, passes ventrad of the mandible and cephalad along the ventral surface of the mylohyoid muscles close to the mandible, dividing into two branches which supply the gular and oral lines of lateral line sense-organs.

The fourth branch mentioned by Fischer as *ramus jugularis,* is the *ramus hyo-mandibularis* of later writers. As in other amphibians it receives the *ramus communicans IX ad VII.* The ramus hyo-mandibularis in Cyptobranchus does not contain all the elements demonstrated by Strong in the nerve of that name in the frog, since, as indicated above, the *ramus mandibularis externus* and *ramus mandibularis internus* are separate rami as far back as the facialis ganglion. Ramus hyo-mandibularis pierces the cephalic division of m. depressor maxillae inferioris to which it gives several small twigs, then trends ventrad breaking up into numerous small branches in m. mylohyoideus posterior. The ramus is thus in the main motor but a few sensory branches pass to the skin over m. depressor maxillae inferioris, and probably there are sensory branches to the skin under the jaw. Strong has shown that in the frog these sensory fibres are derived from the ramus communicans IX ad VII.

Nervus acusticus. The auditory nerve of Cryptobranchus has the usual close relation to the facial. Its distribution is beautifully described and figured by Retzius in Vol. I of *Das Gehörorgan der Wirbelthiere.*

Nervus glossopharyngeus. The most cephalic branch of the glossopharyngeus is *ramus communicans IX ad VII.* This ramus trends latero-cephalad and unites with the ramus hyo-mandibularis at about the point of entrance of the latter into m. depressor maxillae inferioris. The next division consists of several slender branches passing dorsad to the skin on the dorsal surface. Since this division innervates the region of the occipital group of lateral-line sense-organs there is a possibility that it represents the *ramus supratemporalis* of Strong.

The ramus immediately caudad of the preceding is a slender branch which passes ventrad to the mucous membrane of the roof of the pharynx. It can be traced cephalad as far as the post-nasal process, lying close to a blood-vessel between the pterygoid bone and the mucous membrane of the roof of the mouth. Herrick finds a somewhat similar ramus in Amblystoma which anastomoses with the ramus palatinus VII. This ramus seems to be the ramus pharyngeus of Fischer.

The *ramus lingualis* lies furthest caudad and is much the largest of the glossopharyngeus branches. After passing latero-caudad over the hyo-suspensorial ligament it gives off a slender cutaneous branch, which anastomoses with a somewhat similar branch of the vagus, supplying the skin cephalad of the branchial cleft. After giving off the cutaneous branch the ramus enters m. hyobranchialis to which it gives a motor branch, then, emerging from the muscle, it passes dorsad of the hypo-hyal cartilage and enters the tongue, near its cephalad border. Occasionally the r. lingualis merely lies on the ventral surface of m. hyo-branchialis, only the motor branch penetrating the muscle. Thus the ramus generally called lingualis is a mixed nerve.

Nervus vagus. As my study of the vagus is not yet as complete as it is possible to make it even by gross dissection, I shall not attempt a description of all its rami.

The most cephalic branch gives fibres to the skin cephalad of the branchial cleft and anastomoses with the branch of the glossopharyngeus which innervates the same region. There is also a small motor branch running cephalad to m. constrictor arcuum branchialium, and to the caudal part of m. genio-ceratoideus. Another slender branch passes to m. levator arcuum branchialium and to the skin caudad of the branchial cleft.

The largest ramus includes the ramus visceralis and a large recurrent branch. This latter branch is the one figured by Fischer as the hypoglossal nerve, and he was probably at least partially correct, as this nerve receives an anastomosing branch not only from the first but also from the second and third spinal nerves. The greater part of the fibres of this nerve are, however, plainly derived from the vagus. and probably represent a *ramus recurrens vagi.* It gives branches to m. constrictor pharyngeus, m. depressor arcus branchialis posterioris and m. dorso-laryngeus, then runs cephalad and appears to end in m. genio-hyoideus. A branch to m. sterno-hyoideus is also derived from some part of this vago-hypoglossal complex. The most caudal ramus of the vagus is a lateral line branch.

The first spinal nerve has no dorsal root, its origin is almost at the level of the foramen magnum, and it takes its exit by a foramen in the first vertebra. It gives several small branches to the m. longissimus dorsi of the neck region, but the largest ramus is that which anastomoses with the ramus recurrens of the vagus. There are also anastomosing branches which unite this branch of the first spinal with the second and third spinal nerves. The last two have dorsal roots, and the third takes part in forming the brachial plexus. Communication between vagus and hypoglossus has been discovered in larval Anura but it has not been described, so far as I am aware, in Urodela. Most of the material at my disposal was injured in the neck region so that the relations of these parts could not be clearly ascertained. Many points regarding the intimate relations of vagus and hypoglossal nerves will require a study of serial sections for their elucidation.

ON THREE POINTS IN THE NERVOUS ANATOMY OF AMPHIBIANS.

J. S. Kingsley.

With three figures.

In my studies of the head of Amphiuma, which I hope to have completed at an early date, I have found it necessary to make comparisons with the results of other observers, and in some cases to repeat their observations, especially in those cases where Amphiuma presented features not easily reconciled with the conditions existing in other foms.

For this purpose I have had to go over the results obtained by von Plessen and Rabinowicz in their classic "Die Kopfnerven von Salamandra maculata." Studying larvae of this species, varying between two and a half and three centimetres in length, these authors figure and describe a commissure as existing between the ramus palatinus of the facial and their supra-maxillaris superior of the trigeminal, a condition which is not easily reconcilable with what I find in Amphiuma nor with what other authors find to exist in the Urodeles. To test the question as to whether Salamandra maculata was unique in this respect I sectioned a larva of twenty six millimeters and plotted the sections in the same manner as these authors did. As a whole I can confirm their results, but there are a few features which need correction. In their figures they give a small nerve, designated by the letter *z*, forming a ramus communicans between the mandibularis and the maxillary (their supra-maxillaris superior) nerves. In my studies this ramus communicans also occurs, but, instead of its being very small it is fully as large as the branch from the "nebenganglien" with which it connects. Detailed study of many Urodeles shows that the maxillaris must be regarded as a compound nerve, with both facial and trigeminal components. See fig. 1.

Still further in front von Plessen and Rabinowicz describe a nerve uniting the maxillaris with the palatine. As such a ramus communicans occurs in no other Urodele which I have studied, this condition was also investigated. In all other Urodeles the connection occurs between the opthalmicus profundus (the nasalis of von Plessen and Rabinowicz) and the palatine, a condition which is not found in their figures or description. In this I think they have made a mistake and that a part of their error has arisen in this manner. In Salamandra, near the anterior limit of the eye the maxillaris nerve comes to lie close against the inferior oblique muscle at its insertion on the ball while the middle branch (their *b*) of the ophthalmicus profundus lies against the same muscle near its origin. It therefore appears possible that they have mistaken the muscle for a part of the ramus communicans, a mistake the more readily made since in many forms there is such connection between the maxillaris and the palatine. The true relationship may be seen from fig. 2, which shows the middle division of the ophthalmicus profundus connected with the palatine by a short transverse commissure, just as is the case in Amblystoma, (my studies confirming the results of Herrick in this respect) and in Amphiuma and other forms. In Salamandra maculata, in front of this ramus communicans, the middle branch of the opthalmicus profundus suddenly bends downwards and goes to

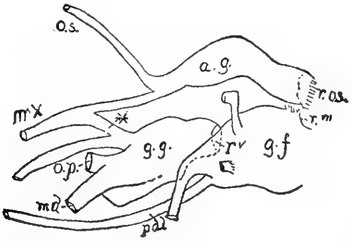

Figure 1. Lateral reconstruction of the proximal portions of the fifth and seventh nerves of a Salamandra maculata embryo, body length 26 mm. *ag*, accessory ganglion of VII; *gf*, ganglion of facialis; *gg*, Gasserian ganglion; *md*, ramus mandibularis; *mx*, ramus maxillaris; *op*, ophthalmicus profundus; *os*, ophthalmicus superficialis; *ros*, root of the ophthalmicus profundus; *r* v, root of the trigeminal; *r* VII, root of the facialis; *, ramus communicans between the mandibularis and maxillaris nerves. x 30.

the alveolar region of the upper jaw, while the palatine is continued forward as described by these authors, passing just inside the internal nares, and forward and beneath the premaxillary bone.

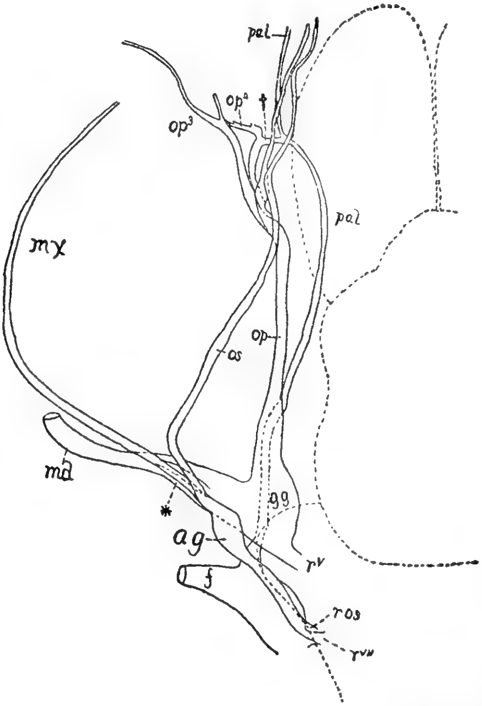

Figure 2. Projection of fifth and seventh nerves of Salamandra maculata, viewed from above; letters as before excepting op^2, op^3, middle and outer divisions of the ophthalmicus profundus; †, ramus communicans between palatine and profundus nerves. x 30.

In the Journal of Morphology Vol. XI, No. 2, Mr. Alvin Davison gives an account of some features in the anatomy of the young and of the adult Amphiuma. It is unnecessary to notice here the whole article but there is a point of nervous anatomy mentioned which may fittingly be commented upon in a Journal devoted to neurological matters. Mr. Davison says (p. 401): "The most important and interesting structure is found below and external to the eye in my smallest specimen, seventy eight millimeters in length. There appears in this region a canal, one tenth of a millimeter long, which is walled by columnar epithelial cells extremely regular in outline. External to the epithelial wall there is seen a thick layer inferiorly of degenerated tissue, which is bounded by a thin layer of fibrous connective tissue. In three other specimens, eighty eight, ninety and ninety two millimeters respectively, no trace of this degenerate canal could be discovered, and in the smallest specimen I was able to detect it on the right side only."

In all probability it is this structure to which he refers later in his paper (p. 405). After briefly summarising Wiedersheim's observations on the tentacular apparatus of the Gymnophiona he says: "As I have already shown, there exists in my youngest specimen of Amphiuma the atrophied remnants of the tentacular apparatus. The columnar epithelial lining of the canal is very distinct in about one dozen transverse sections through the orbits. In some of the sections I have discovered what I believe to be the degenerated retractor muscle. This apparatus in Amphiuma has precisely the same relative location as in the Coecilians. For some unexplainable reason neither Hay nor Kingsley found this organ in the young embryo. . . The occurrence of this degenerated structure in the young Amphiuma and its complete disappearance in the adult gives unmistakable evidence of the relationship of the Coeciliidae and Amphiumidæ." A single figure illustrates the point made.

Were it true that Amphiuma possesses, either in the young or the adult, rudiments of a tentacular apparatus, the fact would prove of great value to those who would recognize in the Gymnophiona only degenerate Amphiumæ. It is not, however, "unexplainable" why neither Hay nor myself found such a structure *for no tentacular apparatus exists in Amphiuma.* I have considerable material in the way of young Amphiumæ—possibly forty specimens—embracing both younger and older material than that in the possession of Mr. Davison and including some from the same lot as the four specimens at his command. In the first place the structures described and figured by him are not in the proper position for the tentacular apparatus, as a little careful reading of the Sarasin's monograph would have shown him. Secondly had he carefully examined the eye muscles of his Amphiuma he would have found that all are present, while the Sarasins say that the retractor muscle of the tentacle is probably produced from the retractor bulbi.

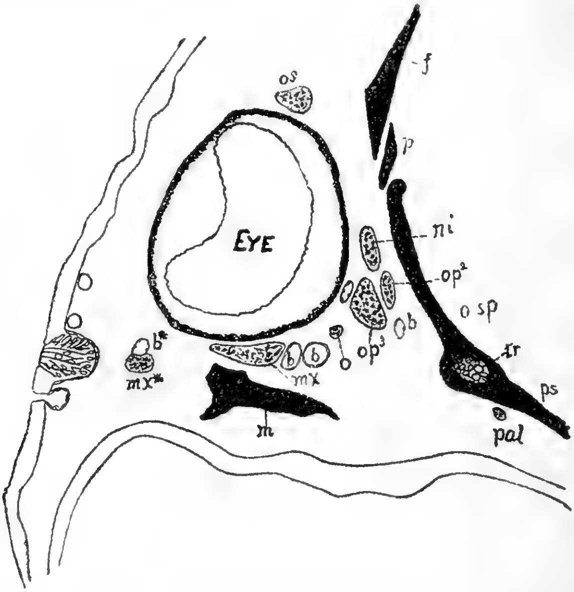

Figure 3. Portion of section through the head of a larval Amphiuma; letters as before excepting *f*, frontal bone; *p*, parietal bone; *ni*, ramus nasalis internus of ophth. profundus; *osp*, orbitosphenoid; *tr*, trabecula; *ps*, parasphenoid; *o*, optic nerve; *m*, maxillary bone; *b*, blood vessel; *b** and *mx**, blood vessel and branch of maxillary nerve constituting the tentacular apparatus of Davison.

On the other hand I find a canal and a solid structure lying immediately beneath it, in the very place where Mr. Davison's tentacular apparatus appears, but I interpret the features differently. The supposed degenerate muscle is a peripheral branch of the maxillary nerve, the tentacular canal is one of the branches of the sub-orbital blood vessels. The only objection to this is that our author describes the canal as lined by columnar epithelium, a condition possibly the result of contraction of the vessel and a consequent throwing of its intima into folds, or possibly he has mistaken the contained blood corpuscles for epithelial cells. The short course which he allows the canal is explained by the fact that distally it breaks up while more proximally it is compressed as it passes between two nerve twigs.

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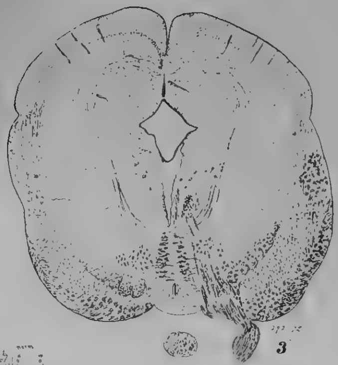

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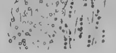

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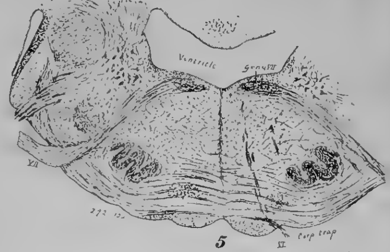

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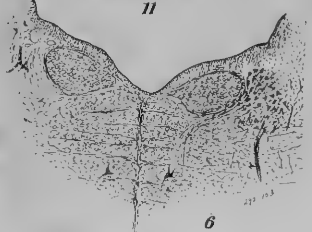

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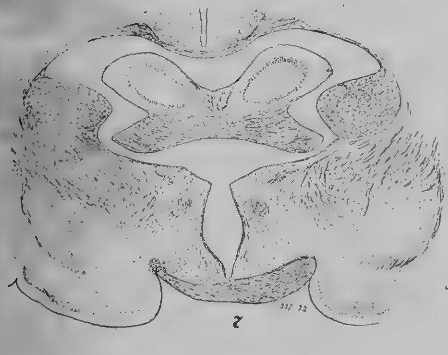

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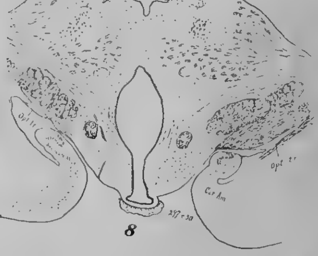

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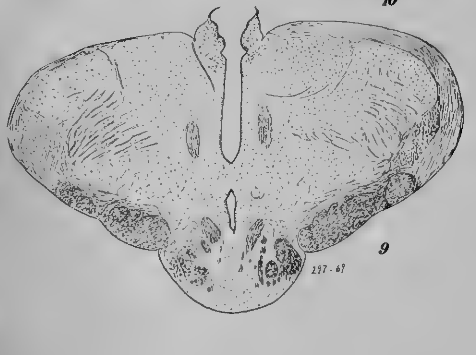

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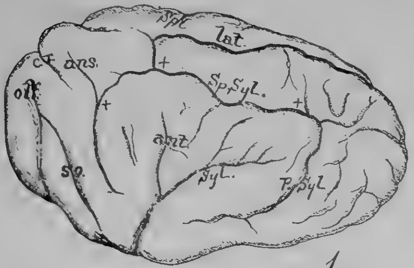

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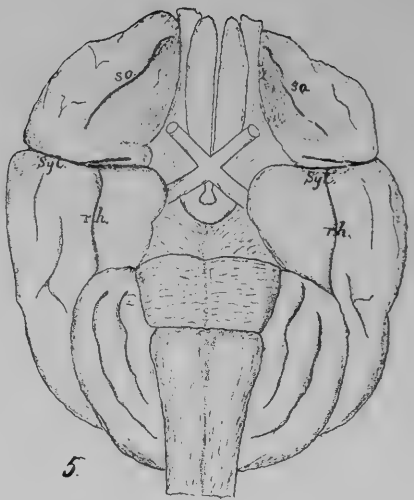

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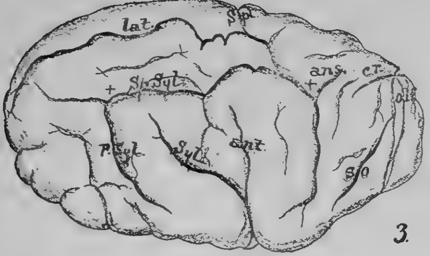

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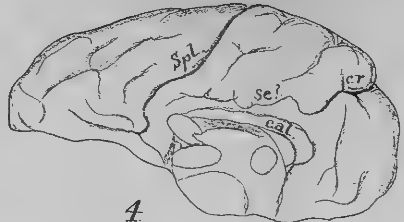

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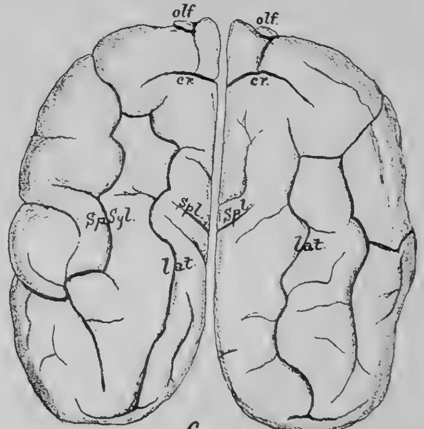

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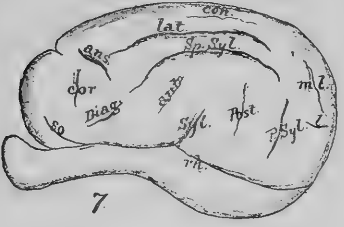

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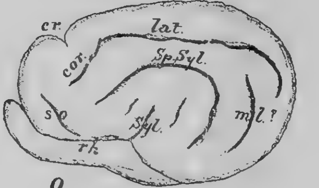

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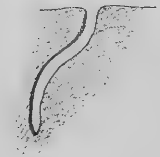

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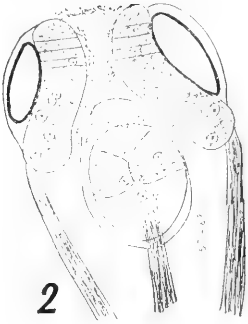

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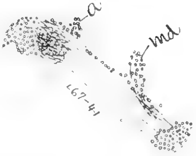

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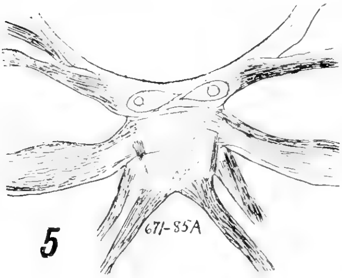

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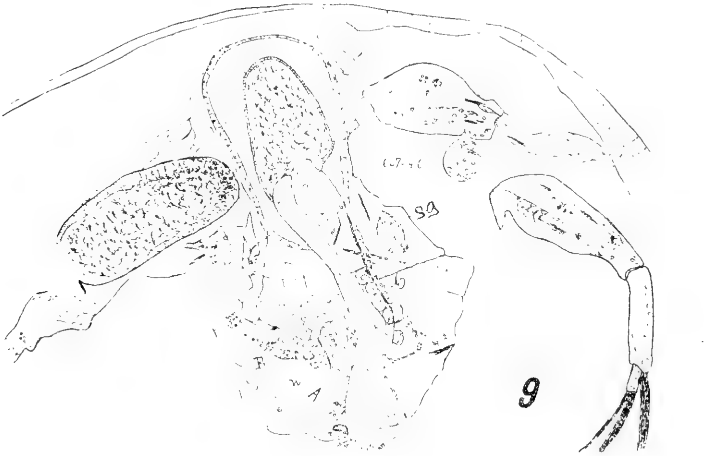

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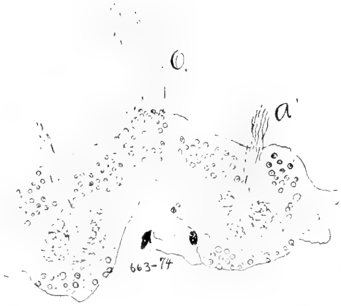

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Journal of Comparative Neurology. Vol. VI. PLATE V.

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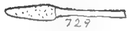

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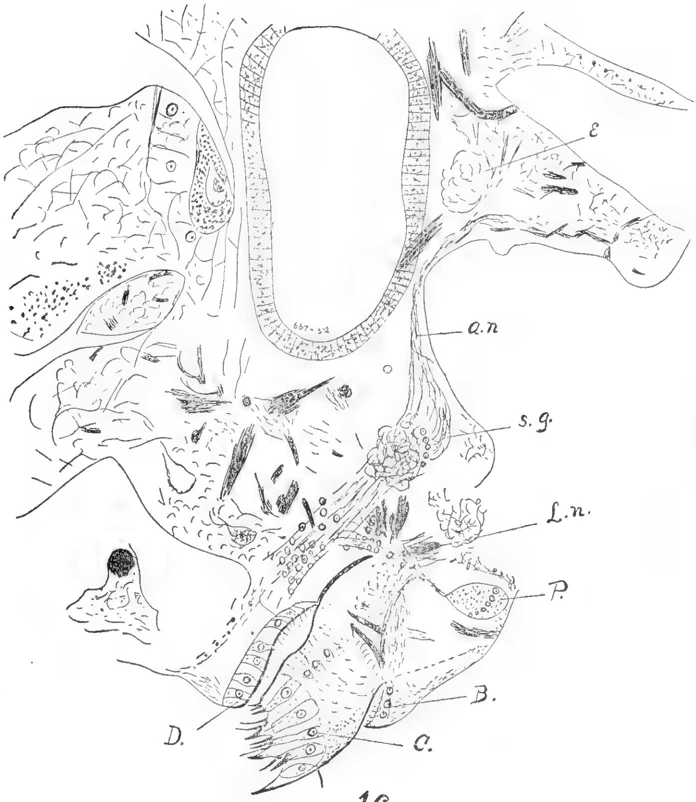

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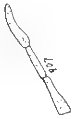

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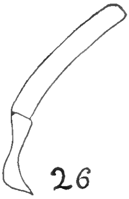

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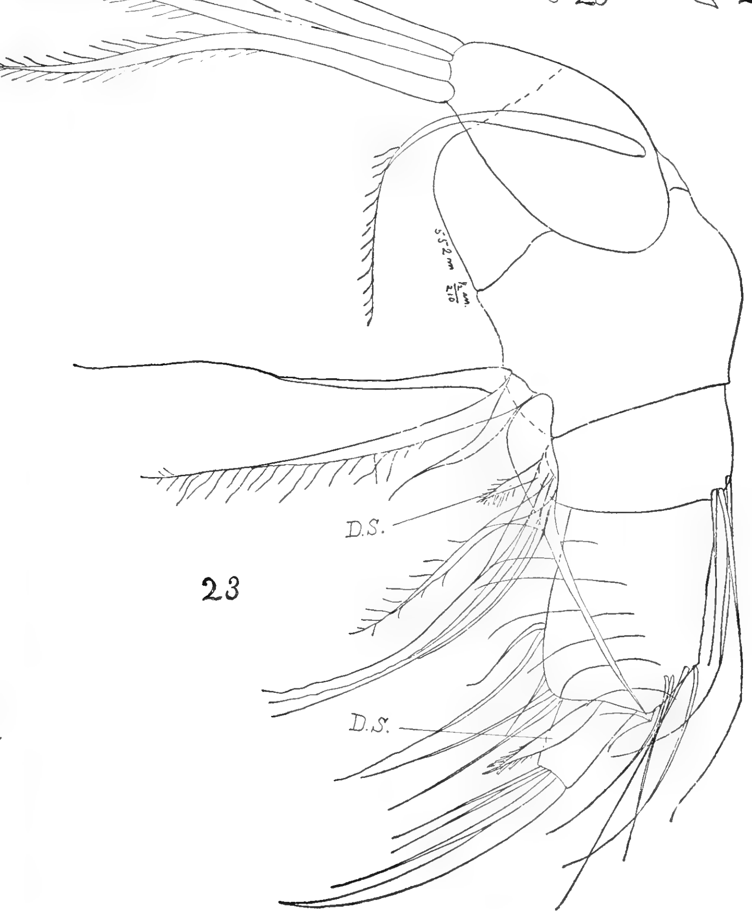

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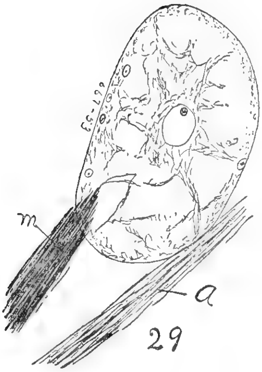

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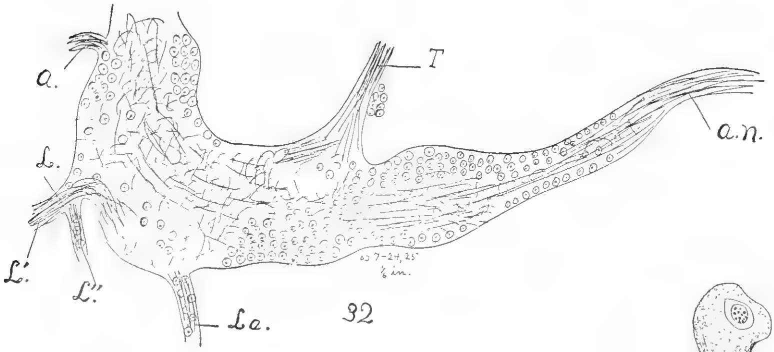

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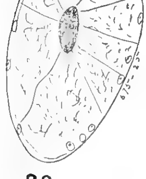

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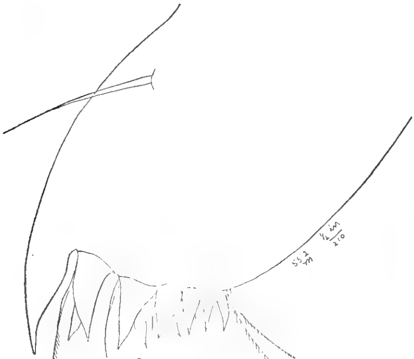

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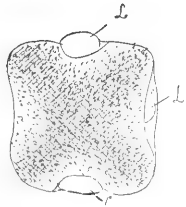

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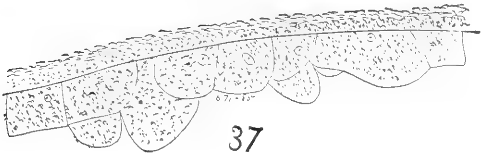

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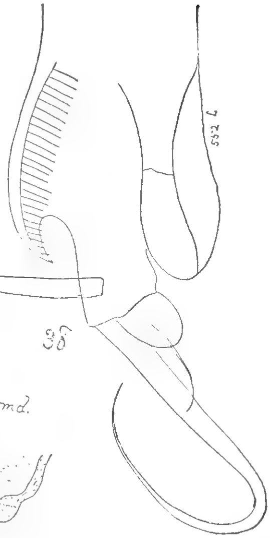

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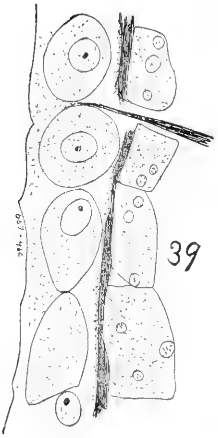

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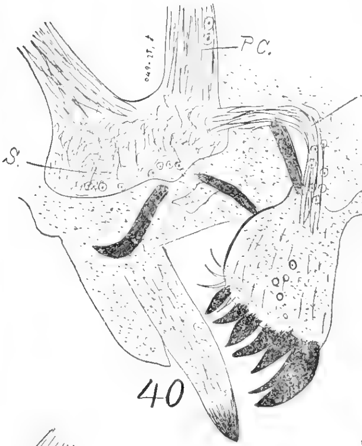

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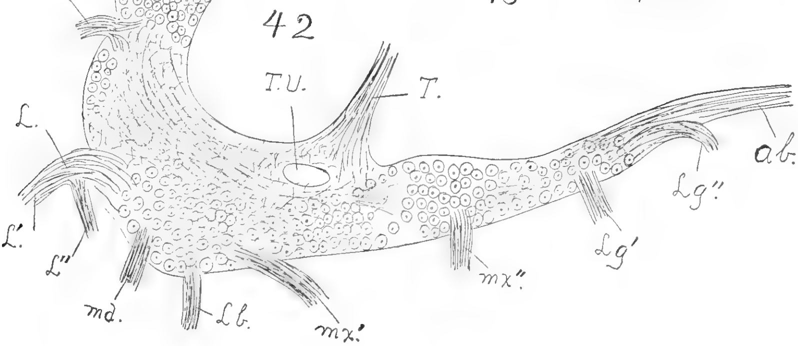

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THE COMPARATIVE ANATOMY OF THE INSULA.

Tracy Earl Clark, B.S.

With Plates IX-XIII.

Table of Contents.

The importance attached to this region of the human brain and the wide divergence of opinion as to the existence of an homologous area in other mammals led the writer, at the suggestion of Professor Burt G. Wilder, to select it in 1890 as the subject for his baccalaureate thesis. The extensive neurologic literature and abundant material possessed by the Anatomical Department of the Cornell University soon convinced the writer of his inability to cover more than the macroscopic side of the subject and that upon a very few specimens. Later the kind offer of Professor Wilder to place at his disposal all of the material at hand led to the prosecution of the work somewhat further.

It is with a keen sense of gratitude that I now acknowledge my indebtedness to Professor Wilder whose advice has been frequently sought and who has always shown great interest in the work. I desire also to thank Professor Simon H. Gage and Instructor Pierre A. Fish for their interest and assistance, and Mrs. S. P. Gage for the loan of specimens.

The following list, while incomplete, will give some idea of the extent and nature of the material upon which the writer has based his conclusions. The accession numbers are the serial numbers in the Accession Book of the Department of Vertebrate Zoology of the Cornell University.

Ac'n No.	*Sex.*	*Age.*	*Groups.*
			SUB-CLASS I. PROTOTHERIA.
			Order I. Monotremata.
76	Male		*Ornithorhynchus anatinus*, duck-bill.
			SUB-CLASS II. METATHERIA.
			Order II. Marsupialia.
			Didelphys virginiana, common opossum. Several specimens.
378			*Macropus giganteus*, giant kangaroo. Two specimens.
1331	Male		*Hypsiprymnus moschatus*, kangaroo-rat.
108	Male		
			SUB-CLASS III. EUTHERIA.
			Order III. Edentata.
			No specimens.
			Order IV. Sirenia.
844	Male	Adult	*Manatus americanus*, American manatee.
			Order V. Cetacea.
670	Male	Adult	*Globiocephalus melas*, pilot-whale, black-fish. Fig. 35.
			Order VI. Ungulata.
2177	Male		*Camelus bactrianus*, Bactrian camel.
2122	Male		*Camelus dromedarius* dromedary. Fig. 22.
776			*Cariacus clama*, fallow deer.
961	Male		*Cariacus virginiana*, Virginia deer, red deer. Fig. 23.
			Ovis aries, domestic sheep. Figs. 32-34. Many specimens.
3408	Female	Adult	*Bos taurus*, domestic cow. Figs. 26-30.
3409	Female	Adult	
3362	Female	Juv.	
		Juv.	
2777			*Equus caballus*, domestic horse.
2840		6 mo.	" " " "
2125	Male	Term	" " " "
2095	Male	Adult	" " " " Fig. 25.
2259	Male	Juv.	*Equus asinus*, burro. Fig. 24.

Ac'n No.	*Sex.*	*Age.*	*Groups.*
			ORDER VI. UNGULATA—Continued.
			Sus scrofa, domestic pig.
			Many specimens.
2123			*Tapirus malayanus*, Malayan tapir. Fig. 31.
			ORDER VII. TOXODONTIA.
			Fossil.
			ORDER VIII. HYRACOIDEA.
			No specimen.
			ORDER IX. RODENTIA.
			Arctomys monax, woodchuck, marmot.
3075			*Castor fiber*, beaver.
			Lepus cuniculus, rabbit.
			Several specimens.
			Mus decumanus, brown rat.
			Mus musculus, common mouse.
			Sciurus hudsonius, red squirrel.
			ORDER X. PROBOSCIDIA.
2181	Female		*Elephas indicus*, Indian elephant. Fig. 21.
			ORDER XI. CARNIVORA.
166 3124		5-8 wk	*Canis familiaris*, domestic dog. Figs. 14-18.
			Many specimens.
277	Male		*Lynx rufus*, American wild-cat, lynx.
157	Female	22 da.	*Felis leo*, African lion.
309	Female	18 yrs.	*Felis concolor*, puma, panther. Fig. 10.
			Felis pardalis, ocelot.
			Felis domestica, domestic cat. Fig. 19.
			Many specimens.
			Hyaena striata, hyaena.
2031	Male		*Procyon lotor*, raccoon. Figs. 11 and 12.
			Several other specimens.
			Mephitis mephitica, skunk. Fig. 20.
			Several specimens.
			Putorius vison, mink.
197			*Putorius domestica*, ferret.
			Phoca vitulina, seal. Fig. 9.
a645	Male	Juv.	*Ursus thibetianus*, Thibet-bear. Fig. 13.
			ORDER XII. INSECTIVORA.
3356			*Condylura cristata*, star-nose mole.
			Sorex platyrhinus, common shrew, shrew mouse.
			ORDER XIII. CHEIROPTERA.
			Vespertilio subulatus, common brown bat.
			Several specimens.
			ORDER XIV. PRIMATES.
265	Female	Juv.	*Anthropopithecus troglodytes*, Chimpanzee. Fig. 7.
			Cercocebus fuliginosus.
			Macacus. Fig. 8.
			Several specimens.
			Numerous preparations of the human brain at various ages. See Figs. 1-6.

HISTORICAL SKETCH.

Vicq d' Azyr (**16**, 1786) seems to have been the first to call attention to this area in the human brain. He refers (Pt. II, p. 26) to it as "the convolutions situated between the Sylvian fissure and the corpus striatum" and again (Pt. II, p. 74) as "the convolutions which accompany the Sylvian fissure." These references would seem to indicate that at that time all that was known was the fact of the existence of certain gyres in that region which, on account of their concealed position, had attracted but little attention; furthermore these are the only references made to this region in his volume of several hundred pages.

Monro (**42**, 1788) pictured three gyres of the human insula seen after the removal of the ventral portion of the cerebrum, but he neither named nor described them.

Hence it remained for Joh. Christ. Reil (1804-1806) to give the first description as follows: "Die Insel hat eine länglichrunde Gestallt." Since that time the area has been known as the "insula" or "island of Reil," although many other names have from time to time been applied to it (see Synonymy, p. 93.)

The insula seems to have attracted little attention during the next half century and it was not until about 1860 that the study of cerebral localization caused increased importance to be attached to it. Until several years later it was supposed that the insula governed, at least in part, the power of articulate speech. Authors had noted that in aphasics there was generally a lesion of the insula and the left subfrontal gyre. They seem not, however, to have taken account of lesions confined strictly to either area and they assumed that the insula had been first affected and that later the lesion had extended into the adjoining area. Broca (**4**) disproved this. By comparing the lesions found in postmortems upon a large number of aphasic patients he reached the conclusion as early as 1861 that the faculty of speech was located in the left subfrontal gyre, still often called "Broca's convolution." During the next seven years a large number of aphasics were examined for the purpose of verification, and in 1868 he published a résumé of the facts upon which he based his conclusion. This discovery naturally aroused great interest in the insula inasmuch as "lesions of the left subfrontal gyre generally extend into the insula," while those (**2**) "confined strictly to the insula are very rare." In 1868 Broca (**4**, 113) pointed out that in aphasics there is almost always a lesion in the caudal half of the subfrontal gyre of either the right or the left side, and that this lesion is sometimes confined exclusively to this area. However, in about one case in twenty this area is apparently perfectly sound, but a lesion exists in the insula or an adjacent gyre with which the subfrontal is continuous. The lesion is located in about 19 out of 20 times on the left side and the right side remains perfectly sound. He had never found a case in which the patient was possessed of this faculty and at the autopsy showed a lesion of both subfrontal gyres. Speech has, however, persisted in some patients where an autopsy showed the total destruction of the right subfrontal. He also said he had noticed several cases of idiots who had never been able to learn to read, where the subfrontal gyre was absent on both sides.

So far as the writer has been able to learn, no satisfactory reason has ever been given for this strange association of the subfrontal region and the insula; yet if, as Meynert (**38**) says, "fibers from the subfrontal gyre pass just entad of the insular cortex," then it would seem very likely that a diseased condition of those fibers sufficient to cause loss of speech would affect the overlying cortex of the insula producing lesions and perhaps a breaking down of the cellular cortex, as frequently happens. A clot of blood, through pressure upon the insula, has also been said to cause loss of speech.

THE DEVELOPMENT OF THE OPERCULUMS.

In 1892, Cunningham (**15**, 78) said of the human brain: "As Mihalkovics has pointed out, it is toward the end of the second month of development that the first signs of the Sylvian depression may be detected. At the same time, it is right to state that its appearance is frequently delayed beyond this stage and I have observed hemispheres well on in the third month with hardly a trace of it." What is later to become the Sylvian fissure is now only a broad shallow furrow deepest near the base of the brain and radiating in a fan-shape dorsad where it disappears upon the lateral surface. Gradually by the growth of what will later form the frontal, temporal and parietal lobes, an overlapping or folding occurs and the fossa gradually narrows until completely closed. What really happens is that by the more rapid enlargement of these lobes in an enclosed space, the intervening broad area in the bottom of the fossa, which early becomes fixed in position, is finally covered and the lips of the Sylvian fissure are brought together. These overlapping portions are the so-called operculums and in the human brain are four in number, namely: the *operculum* arising from the frontal and parietal, the *preoperculum* and the *suboperculum* from the frontal, and the *postoperculum* from the temporal lobe. These overlapping portions do not differ structurally from the surrounding parts, being convoluted and covered with cinerea on both the ectal and the ental surfaces, and the gyres of the ental surface are interdigitated with those of the insula. The dorso-caudal end of the Sylvian fissure is the part first formed and the first as well to become completely closed. This is due to the rapid growth of the operculum and postoperculum.

In 1890 Beer (**1**, 309 (ix)) said: "According to Ecker, Mihalkovics, etc., the Sylvian fissure of the adult is formed by the gradual narrowing of a flat broad depression on the lateral surface of the hemisphere, which is due to arrest of development of the *insula Reilii* in the 3rd month of fetal life." The conclusion that the insular area becomes depressed by a cessation of growth, while favored by many neurologists, appears to me unwarranted. Presumably what happens as stated by Wilder is that there is probably no complete arrest of development, but that the surrounding parts develop much more rapidly so that in a short time they project farther laterad, leaving the insula relatively depressed. While this seems to account for all observed phenomena, the writer is inclined to the belief that one very important factor has been underestimated. During the period when the insula first appears, the brain as a whole is enlarging very rapidly. This enlargement in the region which will later become the Sylvian fissure it is assumed may be due more largely to the expansion of the paracœle than to the thickening of the paracœlian wall by the addition of true nervous substance, which of course is always interstitial. The anatomy of this region would seem to favor this latter conclusion. The intimate connection of the insula with the brain stem is such as to preclude any marked lateral extension and, as the wall of the paracœle is then but little more than membrane, any sudden increase of development, either by addition to the true nervous parietes or by the expansion of the paracœle, would cause the area caudad and dorsad to project laterad giving outline to the insula by the formation of the circuminsular fissure and later the dorsal end of the Sylvian. It also suggests the possibility of finding in a fetus of the fourth to the seventh month an expansion of the paracœle corresponding in a general way to the outline of the rudimentary operculum. The conclusion given above agrees with observations upon the development of this region as described by Cunningham, Ecker and others. It is also further believed that this effect of expansion does not stop here, but that the overlapping of the insula and consequent formation of operculums may be due in part to the expansion of the paracœle, and that the subsequent thickening of the walls by the addition of true nervous substance combined with the effects of growth in an enclosed space may account in part for the continued concealment of the insular area in the adults of Primates and some of the Carnivora.

The exact time of the closing of the Sylvian fissure by the operculums is not known. In 1873, Ecker said it was from the ninth to the tenth month.

In 1888 Mingazzini (**41**) said: "In one brain of the eighth month, I have found the fissure almost completely closed." The condition here presented I think is one of individual difference rather than the rule, as I have examined several brains of this age and have not seen one closed or nearly so.

Broca in 1888 (**4**, 545) said: "This superficial position of the cephalic extremity of the insula has been observed, more or less, in man, upon a great number of new-born children or those of a few months old; after the second year it is rarely seen except upon the brains of idiots and imbeciles (and also in some deaf-mutes)."

The determination of the exact time of closing of the Sylvian fissure in the normal human brain is of considerable morphologic importance as it marks the completion of a period of remarkable growth of these lobes; and in making a collection of brains between the eighth and twelfth months for this purpose as many as possible should be obtained so that individual differences might not induce a wrong conclusion.

The operculums do not always completely close the Sylvian fissure and hence the insula is exposed sometimes even in the adult human brain. In 1887 Rolleston (**49**, 35), in his description of an adult male Australian brain, said: "The island of Reil is exposed on the left side. . . The exposure of the island of Reil implies that the surrounding gyri are ill-developed; Broca's convolution is thus shown to be defective, a point of interest in an Australian savage whose language is primitive as shown by its unclassified character." It is questionable if facts would bear out this conclusion, and while some of the gyres might in this specimen have been "ill-developed" it would have been interesting to learn if this had been observed on any other specimen.

The brain of the philosopher Chauncey Wright has a part of the insula exposed. In 1889 Wilder (**63**,158) said: "Whether any of this condition is due to pressure during hardening which may have occasioned also the peculiar roundness of the temporal lobe, it is impossible to determine and Dr. Dwight does not recall the condition of the parts when the brain was removed." In others, as that of the Swedish carpenter (No. 318), the operculums not only conceal the insula but absolutely overlap each other. These, with the possible exception of the Australian, are all types of individual difference and their significance may be summed up thus: (1) if the insula is not wholly concealed, it shows that if the insula is normal, the surrounding parts have not reached their full development, while if the insula is abnormally large, the surrounding parts may or may not be fully developed; (2) if the insula is completely covered so that the operculums overlap each other, it would appear that, if the insula is normal, the surrounding gyri must be abnormally developed, while if the insula were unusually small, the normal operculums might even overlap each other.

EARLY DEVELOPMENT OF THE HUMAN INSULA.

We have seen that the rudiments of the Sylvian fissure become apparent toward the end of the second month of fetal life. There is then in the bottom of the shallow fossa an indefinitely-defined oval or somewhat triangular area which apparently develops more slowly than the surrounding lobes and which finally becomes a subarea. As development proceeds, this area becomes more elevated and hence more sharply defined by the formation of the circuminsular fissure. The region thus mapped out is sometimes called the *insular area* because it is the part which will eventually become the insula in man and presents a condition found in the adults of some animals.

Mingazzini (**40,** 217, 1888) says: "Until the end of the sixth month the insula is quite smooth; constantly there appear in the seventh month those fissures [circuminsular, Wilder; *rigoles*, Broca] which circumscribe the future gyres of the insula. I can therefore not agree with Mikalkovics who asserts that the insula is smooth up to the beginning of the ninth month. I found this quite so once in a brain of the eighth month upon which only one small cortical fissure appeared. In the eighth month, they increase, oftentimes, to the number of four, among which is produced the caudal one which is larger and deeper than the others; after the ninth month, there are, as a rule, four fissures." Mingazzini probably erred in the above statement. The caudal one of the four fissures on the normal insula is never, so far as the writer has been able to learn, "larger and deeper" than the transinsular fissure which is cephalad of it and the observations of Cunningham (**14**, 347-348) in 1891 seem to show pretty conclusively that even when three fissures are present on this area, the caudal one is usually in the postinsula.

In the spring of 1890 the writer became convinced, as the result of the study of the comparative anatomy of this region, that future investigation would show that, barring the circuminsular fissure, the transinsular, which is doubtless the most constant and best defined of the fissures on this area, would be found to be the first to appear after the circuminsular and that its homologue exists in some other animals at least. The following table compiled from Cunningham, 1891 (**14**, 347-348) seems to prove that this really is the order of development in the human fetus. The brains enumerated below range from five to six and a half months.

State of Development of Insula.	CEREBRUMS		Total	Transinsular f. present.
	Right	Left		
Insula perfectly smooth	2	4	6	0
" with transinsular fissure	3	4	7	7
" " " f. and the one cephalad	6	2	8	8
" " " f. one cephalad and one f. caudad	2	1	3	3
Totals	13	11	24	18

This same author (**14**, 347) says: " Furthermore, there is good reason to believe that in the development of the sulci and gyri the right insula is usually in advance of the left, and also that the process is greatly retarded in the female brain." The first part of the above statement of Cunningham, while apparently borne out by the table, seems remarkable inasmuch as the left insula in the normal adult as usually larger than the right.

In 1892 Cunningham (**15**, 15 summary) said: "In the adult brain the insula is proportionately longer in the male than the female. At all periods of growth it would seem that the insula is relatively longer on the left side than on the right side. In the negro brain, it would appear that the insula is relatively shorter than in the European brain."

The completion of the circuminsular fissure on the ventral side is usually not accomplished until about the time of birth. Prior to this completion of the circuminsular, which is probably influenced to a considerable extent by the cephalic growth of the tip of the temporal lobe, the insula is continuous with the ventral surface of the cerebrum through the Sylvian fossa. It was probably this condition to which in 1885 Meynert (**39**, 4) called attention as follows: "the island of Reil is connected with a protuberance (the olfactory lobe) situated on the lower aspect of the frontal portion of the fore brain." It will be seen (Figs. 1 and 2) that the lateral root of the olfactory tract extends into the Sylvian fossa (that portion of the Sylvian fissure which does not close up). It is not believed, however, that the fibres of this tract extend over any portion of the insula, but on the contrary that they preserve approximately the same relation to the insula as in the sheep (Fig. 34), the skunk (Fig. 20), the cat (Fig. 19) and the mink, in each of which it is to be noted that the fibres do not pass dorsad of the bottom of the rhinal fissure, thus sharply demarcating the insula from the olfactory lobe.

THE ADULT HUMAN INSULA.

Usually the adult human insula is entirely concealed within the Sylvian fissure and can be seen only by divaricating the lips of the fissure or after cutting them entirely away. Broca (**4**, 651) says that it is not normally exposed after the second year. This occlusion is a condition found so far as known in all primates and in many of the imprimates. In all brains possessing an insula, the cortex bends in from the lateral surface and passes without interruption under the fissures and over the surface of the insula completely covering it whether convoluted or not. In all brains observed by the writer, the gyres of the operculums are interdigitated with those of the insula.

In 1889 Wilder (**63**, Prop. CXLI) wrote of this area in man, "the insula is a part of the cortex, which, at one period wholly superficial, is gradually covered more or less completely by converging folds of the adjacent regions. The insula thus becomes a subgyre, while the operculum, preoperculum, suboperculum and postoperculum are supergyres."

The adult human insula is always sharply demarcated by the surrounding circuminsular fissure (*rigoles*, Broca). Its position is generally in a plane nearly parallel with the lateral surface as shown in Figs. 3 and 4. An exception is shown in Fig 5. In this specimen the gyres form a plane nearly perpendicular to the lateral surface. This is a condition found in the sheep, the pig (**12**, 9), the calf, and some horses, and is believed to be due to some peculiarity in the development of the brain stem.

In the adult, the insula is a large broad eminence, the surface of which is richly convoluted. It generally possesses from four to six gyres diverging cephalad, dorsad and caudad and producing an appearance not unlike that of a fan. The number of gyres is subject to considerable variation even in the two insulas of the same brain. The brain of Guiteau, the assassin of Garfield, showed marked peculiarities in this respect. According to Spitzka (**55**, 386) the left insula contained seven fissures and eight gyres, while the right had only five fissures and six gyres. It will be noticed that the right insula had its full complement of fissures and gyres while the left exceeded it by two. Another case markedly different from this one has also been reported by the same author. It, like the preceding, is that of a murderer. He says, the left insula had "fewer and flatter gyri than that [six gyri] of the right side, and was not far different from that of an orang in my possession." In all normal brains, the left insula is said to be larger.

The insula is usually quite deeply fissured and is always divided into two plainly unequal parts. This division is produced by a deep fissure extending dorso-caudad from the ventral side—where it is deepest—to the dorsal margin where it connects again with the circuminsular. This forms a cephalic part, *preinsula*, and a smaller caudal one, *postinsula*. The preinsula is not only larger but contains more gyres. All of the fissures of the insula communicate with the circuminsular dorsad but with the exception of the transinsular none of them reach the ventral margin. The area common to all the gyres of the preinsula, and from which they all appear to spring, is usually the part most elevated and is called the *pole of the insula.* Eberstaller (**17**, 741) says that the "limen insulæ" (pole) is found only or in a certain form in the human brain.

But for the unusually elevated pole in this specimen, Fig. 5 might be said to represent a nearly typical insula. The preinsula usually possesses three gyres of which the first (the one most cephalic) and the third are usually the best developed and these are frequently subdivided dorsad by short fissures. The postinsula seldom possesses more than two gyres the first of which is usually the larger. These gyres are united ventrad and are always longer than those of the preinsula. Eberstaller (**17**, 741) says the first gyre of the preinsula is the largest and strongest and that the second gyre is usually weakly developed. The postinsulas shown in Figs. 3 and 4 exhibit a peculiarity which is very striking when compared with the usually simple character of the area. The three small elevations of Fig. 3 and the one in Fig. 4 dorsad belong to the postinsula. It is possible that the shallow furrows separating these eminences may have been caused by arterial pressure. Fg. 3 also shows the relation of the insula to the medicornu. The specimen shown in Fig. 5 is remarkable for the unusual elevation of the pole. As previously stated this condition is probably the result of some peculiarity in the development of the brain stem.

In 1887 Waldschmidt (**61**, 375) said the insula was larger in educated persons. There are many facts favorable to this view but it lacks confirmation.

Eberstaller and Cunningham have each called attention to the apparently intimate relation of the transinsular and central fissures. These fissures are very constant in the human brain, they lie in the same plane, they take the same general direction and they appear in the fetus at about the same time (5-6 mo.). Eberstaller (**17**, 749, 1887) says: "The cephalic insula is connected wholly with the frontal lobe, the caudal insula with that portion just caudad of the central fissure."

In 1891 Cunningham (**14**, 338-9) said, that Guldberg had suggested for the transinsular fissure "the very appropriate name of *sulcus centralis insulæ* which indicates not only its central position in the island of Reil, but also its relation to the central fissure on the outer surface of the hemisphere mantle." This author then endeavors to establish a connection between gyres and fissures on either side of the transinsular with those on the same side of the central fissure. He further states that "it is true that we cannot regard these corresponding convolutions and sulci as being directly continuous with each other but still in many cases something which approaches very nearly to continuity occurs. Thus it is well known that the inferior precentral sulcus, the fissures of Rolando and the intraparietal sulcus are not infrequently carried downwards, so as to cut into the fronto-parietal operculum and open into the Sylvian fissure." There are many facts which seem to show that Guldberg and Cunningham erred in their conception of the relation of these two areas:

1. The variations in the ventral extension of the central fissure are believed to be due to individual difference.

2. The connection of the central fissure with the Sylvian, when it occurs, is almost always by a small, variable opercular fissure (Cunningham **14**, 341-2). Wilder, in 1894, in the report on the brain of an educated suicide, having apparently duplicate central fissures, says (**65**, 2): "On the left both centrals enter the Sylvian, with a depth of at least 5 mm. On the right, the first central approaches the precentral, the second joins the Sylvian at a depth of about 3 mm." So far as the writer has been able to learn, this connecting fissure never completely divides the operculum nor interrupts the circuminsular fissure in an otherwise normal brain.

3. The absence of the central fissure has not been shown to produce an appreciable effect upon the transinsular and if either is absent it is more often the central fissure.

4. The insula is always sharply defined and is believed to be a distinct lobe as sharply demarcated from the surrounding areas as any lobe of the cerebrum, and the fissures and

gyres upon its surface are also distinct and not dependent upon those of the rest of the cerebrum.

5. The central fissure is not known to exist outside of the primate brain, while, as will be shown, the transinsular fissure is present in many imprimates and the relation of the transinsular to the Sylvian in them is sometimes as in man (see raccoon); but more often it coincides in position and direction with the Sylvian fissure.

6. The transinsular fissure gradually becomes less deep as it approaches the circuminsular fissure dorsad, and it has never been shown to extend beyond this fissure, while in some imprimates it never reaches the dorsal margin of the circuminsular fissure.

7. The central fissure is sometimes double; the writer has been unable to find a single recorded instance of the duplication of the transinsular fissure.

8. The reasons given by Cunningham (**13**, 287) to show that because the preoperculum is (as he thinks) absent in the anthropoid it necessarily follows that a portion of the insula is also absent, are not well founded. The human insula has nearly or quite the same form before as after the appearance of the preoperculum and the writer fails to see why it should be otherwise in the ape.

9. The mononym "transinsular" fissure (Wilder) indicates better the relation of this fissure to the insula and is far preferable to the polyonym "sulcus centralis Reilii" of Guldberg and Cunningham.

The blood-supply of the insula is derived from the branches of the medicerebral artery which ramify over its surface. The main branch lies in the transinsular fissure as shown in Fig. 4. From these branches small arteries penetrate the cortex directly.

THE RELATION OF THE INSULA TO THE CLAUSTRUM.

On account of its intimate connection with the brain-stem, the insula has been called the stem-lobe or *Stammlappen*. Entad of the insular cortex (see Fig. 6) but separated from it by a band of myelinic fibers, lies another cellular area called the claustrum (Burdach). These fibers, says Meynert, have their origin partly from the subfrontal gyre and partly from the uncus from which they radiate in a fan-shape separating the areas referred to above. The same author also says (**37**, 674): "The fibers of the *fasciculus uncinatus* traverse freely the substance of the claustrum as well as that of the *nucleus amygdalæ*. The anterior cord-like and hook-shaped part of the *fasciculus uncinatus* is joined by bundles of fibers distributed, as it were, in layers which pass through and along the surface of the claustrum, constituting an important part of the medullary substance of the island (of Reil) and of the external capsule."

In 1889 Spitzka (**56**, 172) said the claustrum "corresponds in extent nearly with the extent of the insula."

Obersteiner in 1890 (**42**, 68) said of the claustrum, "its lateral surface adapts itself to a certain extent to the cortex of the island of Reil, exhibiting similar small elevations and depressions."

Until recently, the claustrum has been assumed to be peculiar to the primate brain, and was an object of much speculation; but the researches of Betz, Meynert, Duret, Browning and others seem now to prove beyond a doubt that it is really a part of the insula which became separated from the cortex proper by the growth of the fibers referred to above. In 1879 Richet (**48**, 23) wrote: "It appears that in the brains of idiots, the white lamina, which separates the insular convolutions from the *avant-mur* is absent, and the *avant-mur* really becomes the internal layer of the cortex cerebri (Betz)." The same author (**48**, 24) quoting from Duret, says the circulation is the same as that of the insula. Browning in 1889 (**5**, 234) agreed with Duret and stated that the blood supply of the claustrum passed through the cortex of the insula and not through the precribrum (anterior perforated space). This being established it would seem that the presence of a claustrum was indicative of the presence of an insula. It also suggests the possibility of these fibers passing so far entad as not to demarcate a claustrum as is probably the case in the sheep. The former inference regarding the presence of a claustrum indicating the presence of an insula at first seemed plausible but later reflection has caused the idea to be abandoned (see discussion under Carnivora).

THE INSULA IN THE PRIMATES OTHER THAN MAN.

The anthropoid apes, which in structure are so closely allied to man, possess a well developed insula.

Leuret and Gratiolet seem to have been the first to recognize this area. They say (**31**, II, 112): "Le lobe central parait particulier à l'homme et aux singes, peut-etre voit-on quelque chose d'analogue dans les makis, mais on ne voit rien de semblable chez les autres mammiféres."

In 1891 Cunningham (**13**, 287) said: "One of the most remarkable characters in the cerebrum of the orang and the chimpanzee is the total absence of the frontal and orbital opercula. The temporal and fronto-parietal opercula are alone present." There is some diversity of opinion as to the entire "absence" of the suboperculum in these brains and Cunningham also admits the presence of a fissure which forms the cephalic boundary of the operculum but he does not believe it homologous with the presylvian fissure and hence does not recognize a suboperculum. Cunningham (**13**, 287) also says: "It is curious that while the anthropoid should be so absolutely destitute of a frontal and an orbital operculum, there are many of the lower apes (e. g. baboons, macaques, etc.) which show a faint trace of the orbital operculum."

In 1880 Parker, (**46**) stated that the insula of the chimpanzee "is well developed and is marked by several conspicuous radiating convolutions (gyri breves, Gall) and lies entirely concealed beneath a well-developed operculum."

In 1877 Major (**34**, 46) said the insula was relatively as well as absolutely smaller in the chimpanzee, etc., than in man.

Hartmann (**26**, 195) in 1886 wrote that "In the gorilla, chimpanzee, and orang, the island of Reil is generally—at least, according to my experience—overlapped by the operculum, although there are instances in which this is not the case."

In 1878 Broca (**4**, 645) said the insula of the gorilla bears "three gyres as in the orang, while there are four in the chimpanzee." Chapman in 1879 (**8**, 61) said: "The central lobe, or island of Reil, which is very slightly convoluted, is entire concealed in the chimpanzee."

Spitzka (**56**, 255) says that the gyres of the orang's insula correspond as to their direction and relations to those of man, though less marked. He further states that "in every anthropoid dissected by myself, I find these gyri and sulci; and one sulcus is a constant feature of even the Cynocephali."

The specimen here shown (Fig. 7) does not exhibit an area so well marked as those described by the above authors and this is probably due to the undeveloped state of the chimpanzee brain at this age. Excepting the circuminsular, the fissures of the insula are very rudimentary and few in number. This insula was entirely concealed within the Sylvian fissure. There seems to have been a feeble attempt at producing a transinsular fissure but no apparent approximation to a pole. Broca (**4**, 369) says: "L'insula est toujours simple chez les cébiens et les pithéciens, ainsi que chez gibbons. Chez les grands anthropoides et chez l'homme, elle se subdivise en un certain nombre de plis qui convergent vers le pôle et vont gagner successivement les divers points de la rigole supérieure, qu'ils traversent pour se jeter profondément dans le lobe frontal."

Marchand (**36**, 1893) says: "In the lower apes the isle of Reil is exposed. This is the case in microcephalic idiots."

Spitzka (**56**, 173) has shown that the claustrum in present in the baboon and that it is similarly located to that of man.

The insula of the macaque monkey (Fig. 8) shows a well rounded eminence deeply imbedded in the Sylvian fissure. It is sharply demarcated by the circuminsular fissure but is otherwise unfissured and is about twice as long as broad.

Cercocebus fuliginosus presents an insula very similar to that of the macaque. It, like the last-named, shows a well-rounded eminence and a well-defined circuminsular fissure. The insula was deeply imbedded in the Sylvian fissure.

There are several lemurine brains in the Cornell Museum, but they were not available for examination at the time this thesis was prepared.

In 1866, Flower (**21**) said of the Javan loris (*Stenops javanicus*) on separating the lips of the Sylvian fissure "no distinct median lobe, or insula, could be traced." The same author also says "In the sulci of the outer face in the lemur, the Sylvian fissure is deeper especially at its anterior or lower part and conceals a small but distinctly marked insula or median lobe."

ORDERS CHEIROPTERA AND INSECTIVORA.

The specimens belonging to the above named orders, so far examined by the writer, showed no evidence of a macroscopic insula.

THE INSULA IN THE CARNIVORA.

The area which represents the insula in this order is, in general, not well developed, but in a more or less rudimentary form may be said to be fairly constant. As a macroscopic area, however, I have been unable to recognize it in the domestic cat, the Angora cat, *Lynx rufus*, the ocelot (*Felis pardalis*), the skunk (*Mephitis mephitica*), the mink (*Putorius vison*) and the ferret (*Putorius domestica*). My observations made in the latter part of 1893 upon the seal (*Phoca vitulina*) agree with the conclusion of .P. A. Fish (**20** ½, 16, 1896) who has shown that the Sylvian fissure has not suffered any marked displacement and that Spitzka (1890, *American Naturalist*, XXVI, 115-122) erred in assuming a vertical communicating fissure (*v. f.* Fig. 9) as the true Sylvian. The position of the insula shows conclusively that the caudal one of these two fissures is the true Sylvian. Dr. Fish also says: "The vertical and the true Sylvian fissures meet superficially at the latero-ventral angle of the cerebrum and if the sides of the Sylvian be separated, it will be seen that the vertical fissure instead of directly joining the Sylvian becomes a submerged fissure . . . and crops out again on the ventral surface on the front or cephalic wall of the mouth of the Sylvian. . . This condition is found on both sides." The insula is represented in the seal (*Phoca vitulina*) and the panther (*Felis concolor*) in Figs. 9 and 10 respectively. In each the area is devoid of fissures except the circuminsular, thus indicating its very rudimentary character. The area is only slightly elevated and was entire concealed within the Sylvian fissure. It is present and of about the same rudimentary character in the hyena where it is flatter than in the preceding and is entirely concealed. It is concealed and rudimentary in the lion. In 1879 Pansch (**45**, 166) said that it is present but concealed in the fox.

Fig. 11 represents this area in the raccoon. The circuminsular fissure is interrupted at two points leaving the insula joined to the temporal lobe caudad and the cephalic boundary ill defined. This elongated and flattened area is crossed by a fissure which is believed to represent the transinsular, although it does not correspond exactly with the direction of the Sylvian (see Fig. 12), as is usually the case in the imprimates at least. Nevertheless it almost completely divides the area into a preinsula and a postinsula, is deepest at its junction with the rhinal and at that point it corresponds in position with the Sylvian. This lack of conformity is strongly suggestive of a displacement of the Sylvian fissure as the result of growth in an inclosed space which may have carried the dorsal end of the Sylvian caudad while the bounding parts of the ventral end, which is more closely connected with the brain stem, have maintained their original position. Future investigation may also show that some peculiar development of the frontal or parietal lobes or of both has aided in bringing about this condition. The relation of the transinsular to the Sylvian fissure in this brain is strikingly similar to that in the human, but in the raccoon there is no evidence of the central fissure. The area is otherwise unfissured, but slightly elevated and, with the exception of the cephalic third which lies concealed in the Sylvian fossa, it is completely hidden within the lips of the Sylvian fissure. As previously stated, the cephalic boundary is ill defined and the insular area graduates out into the frontal lobe as in the case of young pigs. The plane (plane of fissured surface) of the insula in this specimen forms an angle of more than 45° to the lateral surface while that of the seal, panther, hyena and most primates is nearly parallel to the the lateral surface.

The insula of the Thibet bear (*Ursus thibetianus*), Fig. 13, is very different in its appearance from the preceding—as if, instead of the prolonged growth caudad, as in the raccoon, the surrounding areas which presumably have reached a higher state of development, had produced a cephalo-caudal compression of this area, resulting in the formation of two parallel gyres separated by the transinsular fissure. Relative to the length of the cerebrum, the insula in this specimen is much shorter than that in the raccoon. The transinsular fissure here is deep and coincides very closely both in direction and position with the Sylvian. The area is sharply demarcated by the circuminsular fissure except at the cephalic end where a slight depression probably marks the cephalic boundary. The area is well rounded and the plane of the insula is parallel to the lateral surface. The insula was not wholly concealed, a small portion of the caudo-ventral end of the cephalic subgyre being visible before dissection. The area was almost entirely within the Sylvian fissure. In 1888 Turner (59, 566) said: "In the brain of the Polar Bear, I have shown that an entire arched convolution is concealed within that [Sylvian] fissure."

This area in the dog (*Canis familiaris*) is situated normally at the bottom of the Sylvian fissure and is entirely concealed. The plane is parallel to the lateral surface or nearly so. It is a well rounded, oval area somewhat triangular in form, is sharply defined by the circuminsular fissure and, as stated by Huxley, is usually unfissured. Figs. 14 and 15 represent an exceptional condition. The insula was exposed on both sides and was situated almost wholly in the Sylvian fossa. The area was well rounded and its outline approximately rectangular. Another peculiar specimen is shown in Fig. 16. Here the insula, while entirely concealed within the Sylvian fissure, was crossed by a fissure which may represent the transinsular fissure and if so the preinsula is the smaller. In order to determine with greater certainty the nature of this fissure the area was removed and sectioned. The shallowness of the fissures (Fig. 17) plainly shows that the fissure crossing this area is not a part of the circuminsular but an independent fissure, probably the transinsular as previously stated. The small area cephalad undoubtedly represents a preinsula. Owing to the normally simple character of this area in the dog, these individual differences are very striking.

A transection of the cerebrum of a dog is shown in Fig. 18. The insula appears as it normally exists concealed by the overlapping portions of the temporal and parietal lobes. The myelinic fibers of the olfactory tract readily distinguish the rhinal fissure and it will be noted that they do not extend beyond the bottom of this fissure. A band of myelinic fibers extending apparently from the dorsal overlapping area of the parietal lobe, passes through the insular cortex cutting off the ental layers which constitute an area probably homologous with the claustrum. The study of sections caudad of this one shows that this band of fibers ventrad of the insula bends around into the temporal lobe. It would thus appear that a part of them at least might be association fibers. Fibers also given off from this band are distributed through the claustrum. Myelinic fibers are also found in the ectal dense layer of cortex of the insula and they extend for the most part parallel with the surface.

The insula receives its blood-supply directly from minute branches of the medicerebral artery, which pass in from the surface and which are seen in longisection in Fig. 18. The writer has been unable in most cases to determine the origin of vessels found in the claustrum as they were seen only in transection. A few however have been found which passed directly across the area as in the case of the one represented in the dorsal end of the claustrum. These would seem to indicate that a part of the supply might be received directly from the surface arteries. In the vicinity of the fiber tracts, arteries, in general, seem to follow the direction of the length of the fibers and not to cross them.

As previously stated, no macroscopic area appears at the bottom of the Sylvian fissure of either the cat (see Fig. 19) or the skunk (Fig. 20). In each the width of the Sylvian fissure is practically the same throughout its length and at the bottom as near the surface. The study of many transections of the Sylvian region confirms the statement that there is no marked widening of the Sylvian fissure at any point ; there is absolutely no sign of a circuminsular fissure and consequently no evidence of an ectal area homologous with the insula. Recourse was then had to the Weigert method with the result that it has been demonstrated in each that a cellular area had been separated from the cortex entad of the Sylvian fissure by a thin lamina of myelinic fibres. This area is similarly situated to the claustrum of the dog and in the skunk at least the fibers appear to arise from the area dorsad of the Sylvian and pass to some area ventrad or *vice versa.* In the cat, however, this lamina appears to connect the area ventrad of the Sylvian fissure with the central mass of myelinic fibers rather than with the area dorsad of the Sylvian. The origin of these fibers does not effect the question as to whether or not this is really a claustrum for, while it is known that fibers from the uncus and subfrontal gyri pass entad of the insula and assist in the demarcation of a claustrum in the human brain, it is not known but what fibers having a different origin also take part. Certain it is that if these myelinic fibers (which appear to be of the association type in the dog and skunk) were not there this area would remain a part of the cortex as has been shown is sometimes the case in the human brain. The fibers which make up this lamina are much fewer than in the dog and the number is still less in the skunk than in the cat. Some twelve days after I had thus independently reached the conclusion that this area was homologous with the claustrum, my attention was called by Professor Wilder to an article by Graeme M. Hammond, in 1881 (**26**). This article contains figures showing that the author had noticed the area in the cat, sketched it though imperfectly and named it the claustrum. In 1889, Spitzka (**56**, 173) also figured this area in the cat but did not name it. The writer was unable to recognize a claustrum in (Weigert) transections of the brain of the mink. This animal has no Sylvian fissure.

The significance of the presence of the claustrum is difficult to determine. As previously stated, the existence of a claustrum might, in general, be taken to indicate the presence of an insula but such is not believed to be true in either of these instances. Presumably if a rudimentary insula did exist in the cat, then only a small portion of the claustrum would correspond therewith; and if only a part of the claustrum belongs to this area, then, as in this case where the claustrum is of considerable size, the larger part of the claustrum has necessarily no conection with the insula. Indeed it might exist quite as well without an insula. Hence it would appear that the only significance attached to the presence of a claustrum in such cases is that the cortex at the bottom of the Sylvian fissure is relatively farther entad than in those brains where the area is not so demarcated, as in the sheep and mink.

Turner in 1888 (**59**, 566) said: "In the true carnivora, the Sylvian convolution was, as a rule, superficial and on the cranial aspect, though in the otter and badger indications of the depression of its anterior limb within the fissure were seen. In the seals and walrus, the concealment of this convolution was still more marked, so that the brains of these animals form apparently, in this particular, a transition to those of man and apes, in which the concealment of the island is complete."

THE INSULA IN THE PROBOSCIDIA.

In the single specimen of the Indian elephant examined by the writer, the insula (Fig. 21) is only slightly developed. It consists of an almost flat area in the bottom of the Sylvian fissure and is made up of three gyres, two of which belong to the postinsula. This disposition of the insular area suggests that in the unusual dog (Fig. 16) except that in the latter the postinsula is at the same time more elevated. In the elephant the postinsula contains the greater number of gyres but the preinsula is the more elevated. The entire area is deeply imbedded in the Sylvian fissure and extends ventrad as far as the rhinal fissure. This observation is contrary to that of Owen, 1868, who declares (**44**, 129) that "the minor inter-Sylvian convolutions are exposed in the sheep and elephant." He also says (**44**, 123) "It is well marked and rises high up the Sylvian fissure in the Proboscidians." In 1879 Spitzka (**52**) said that the insula in the elephant is completely covered. The largest branch of the medicerebral artery lies in what I have called the transinsular fissure but this artery does not reach the dorsal margin of this area. At about one-half or two-thirds of the distance from the ventral boundary of the insula, the artery leaves the area to pass dorsad into the Sylvian fissure. This peculiar condition seems to have been brought about by the very unusual growth of the area dorsad of the insula, which fold has been projected ventrad as a rudimentary subopercular fold.

THE INSULA IN THE RODENTIA.

None of the members of this order so far as examined by the writer showed any evidence of a macroscopic insula. Transections of the Sylvian region prepared by the Weigert method failed to show the presence either of an insula or a claustrum in the woodchuck.

THE INSULA IN THE UNGULATA.

With the exception of the primates, members of this order seem in general to have reached a higher state of insular development than those of any other order, a significant fact when it is considered that this order is usually placed so far down the list on account of other characters. The specimen of the camel here shown (Fig. 22) can hardly be taken to indicate much more than the existence of an insula in this animal. The area is nearly flat and presents no fissures other than the circuminsular. The insula is proportionally very small and shows on the whole a rudimentary state of development compared with the surrounding lobes. It was completely concealed within the Sylvian fissure, the ventral end scarcely reaching the rhinal fissure; the wider end of the insula is dorsal. It is concealed and rudimentary in the bactrian camel (*Camellus bactrianus*).

The deer (No. 961) presents a well defined area and at the same time one not indicating a high degree of development. The insula (Fig. 23) was completely concealed and is situated almost wholly in the Sylvian fossa, only the caudal end extending dorsad into the Sylvian fissure. With one exception the fissures are merely broad shallow depressions which indicate a tendency to divide the area into five gyres. The caudal fissure probably represents the transinsular and is the only one indenting the lateral surface of this area. The plane of the insula is nearly perpendicular to the lateral surface; the surface is well rounded and throughout its entire length lies just dorsad of the olfactory tract. The insula is present also in the fallow deer (*Cariacus clama*) and exposed on both sides. At least three fourths of the insula is cephalad of the ventral end of the Sylvian fissure. The transinsular fissure is rudimentary on the left side but better developed on the right. The difference in the position, relative development, form, and relations of the insula in the camel and deer are very great and more marked than one might expect in animals so closely related.

The area which represents the insula in the sheep (Figs. 32-33) is, contrary to the rule, exposed. It is probably due to this fact that this area has not previously been treated by writers on the sheep brain. Only Leuret and Owen seem to have recognized it. The former states that, except in the sheep, they [supplementary convolutions] are found "only in the brains of man, elephant and monkeys." Owen says: "the minor inter-Sylvian convolutions are exposed in the elephant and sheep."

This area, as has been rightly said, is exposed in the sheep and throughout its length lies just dorsad of the olfactory tract in the Sylvian fossa. The rhinal fissure which separates these areas is always well defined. In adults the lateral exposed surface is usually indented by two (apparently three) fissures—the most cephalic and caudal being found upon dissection to be parts of the circuminsular, while the median one is the lateral outcrop of what the writer considers the homologue of the transinsular fissure. Other indentations are frequently noticed but they are usually slight and are probably caused by pressure of branches of the medicerebral artery which lie in them. Upon dissection, it becomes evident from the greater fissuration that the dorsal and not the lateral surface is homologous to the lateral areas of most mammals and that the plane of the insula is perpendicular to the lateral aspect. Presumably in this brain as in the human the circuminsular fissure is the first developed and in adults is usually complete. In younger specimens however it is quite noticeable that this fissure is interrupted in one or more places as on the lateral surface at the cephalic end of Fig. 32 and at the dorso-caudal boundary of Fig. 33. With the exception of the circuminsular but one fissure of this area appears to be constant and is the only one extending upon the lateral as well as the dorsal surface. This fissure is continuous with the rhinal; in it lies the largest branch of the medicerebral artery which passes dorso-mesad into the Sylvian fissure; it coincides throughout most of its course with the direction of the Sylvian, divides more or less completely the area into a preinsula and a postinsula and is the fissure which, in the discussion of the lateral surface, was called the transinsular fissure. This branch of the medicerebral artery after traversing nearly two thirds of the length of the transinsular from the lateral surface mesad suddenly leaves it and passes up into the Sylvian fissure, thus giving the appearance as if the nearly equilateral triangular caudo-mesal portion of the caudal gyre of the preinsula had grown caudo-ventrad of the artery. Presumably what has happened is that a displacement of the Sylvian fissure has occurred due to a greater development of the temporal or occipital lobes than the frontal and parietal; that this growth in an inclosed space has resulted in carrying cephalad the dorsal end of the Sylvian and with it the artery, thus removing the artery from the mesal end of the transinular, where presumably it originally was lodged. The vertical position of the Sylvian fissure would seem to indicate that such a displacement had occurred. The relation of the Sylvian to the transinsular fissure is very striking when compared with that in the raccoon, where the Sylvian was mostly caudad of the transinsular. In two instances only have fissures other than those above mentioned been seen on the lateral surface of the sheep brain and in each case, as might be expected, they were in the preinsula.

The dorso-lateral aspect (Fig. 33) shows the preinsula to consist of three gyres while the postinsula has but one. The gyres of the insula are in general simple. One specimen, however, showed the caudal gyre (postinsula) subdivided into three parts. The fissures grow deeper as they approach the meson except the transinsular but it is not known that any are constant. The sheep brain exhibits two unusual conditions shown in the transection of this brain (Fig. 34): first, that a bundle of myelinic fibers enters the insula from which it might be inferred that this area is functional, or at least assists in the performance of a function. These fibers seem to pass principally to the dorso-lateral part of this area, although it is evident that many are given off along its course to other parts of the area mostly dorsad. Secondly, there is no indication of a claustrum. It is not believed that any great significance can be attached to the apparent absence of this part in the sheep other than that the insula in this animal is relatively farther laterad than in those where the claustrum becomes so demarcated and hence the fibers from surrounding areas which in some other animals pass through the cortex here pass wholly mesad. The blood supply is derived wholly from branches of the medicerebral artery which extend over the surface. The position of the rhinal fissure and the relations of the insula to the olfactory tract are clearly shown. The myelinic fibers of the latter extend only to the bottom of the rhinal and in no case have fibers been found extending upon the insular area. This fiber area of the olfactory tract extends considerably farther ventrad than shown (Fig. 34) and at the ventral end the fibers are most numerous and collected into a bundle of considerable size.

The insula of the cow (Figs. 26-29) is well developed, exposed on the lateral aspect and lies almost wholly within the Sylvian fossa. It presents in this animal peculiarities not previously met with. The area in but one of five specimens was completely divided into a preinsula and a postinsula. In this one (3362) the transinsular fissure was well marked, was deepest at the latero-ventral end, and was continuous mesad with the circuminsular. The fissure cephalad of the transinsular also completely crossed the insula but was shallow at the ventral margin. The area is more often incompletely divided by the transinsular fissure which, while it is of considerable length and depth, is almost always confined to the lateral surface. The part most elevated in the five specimens examined lies in the postinsula always directly caudad or caudo-mesad of the dorsal end of the transinsular fissure. What has been assumed as the plane of the insula is at an angle somewhat greater than ninety degrees with the lateral surface. The caudal and caudo-lateral surfaces of this elevated portion slope very abruptly from the apex of this elevated portion to the temporal lobe. The slope toward the mesal boundary is always more gradual and becomes still more so as the cephalic boundary is approached. A curious condition exists at the caudal end of the preinsula where, on the lateral surface, the appearance is as if a quite successful effort had been made to tuck that part caudo-mesad under the postinsula. This is more marked on the left side (see Fig. 26) than on the right (Fig. 27), and the crowded appearance of this area seemed more marked in adult than in younger specimens. The surrounding lobes appear to be well developed, while the olfactory tract is enormous. The study of this brain seems to confirm the impression that these remarkable features are due to growth in an enclosed space. The insula shows the effects of compression in a marked degree.

The circuminsular fissure of the right side (Figs. 27-28) sharply defines the insular area except at the temporal lobe where the fissure is interrupted and a junction of the insula with the temporal lobe is formed at the lateral surface. This insula consists of seven gyres only one of which belongs to the postinsula. On the left side of the same specimen (Figs. 26 and 29) the circuminsular fissure is also interrupted with the formation of a similar junction as on the right side. Two interruptions of the circuminsular are found at the cephalic margin on the left side. The dorsal surface is divided into four gyres, three of which belong to the preinsula. A zygal fissure[1] (Fig. 29, *zf*) exists near

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[1] See Wilder (**64**, 155).

the middle of this area, the base extending in the direction of the length of the area. While this surface is much less fissured than the corresponding surface of the right side, the lateral surface of the left side appears much more complicated. In the left insula of the cow (3137) the transinsular fissure was wholly exposed on the lateral surface; there was no interruption of the circuminsular at the cephalic margin, and the dorsal surface presented five gyres, four of which belong to the preinsula.

In 1890, Turner (**61**, "Fig. 26") gave a wrong idea of the Sylvian fissure (see Fig. 30) in the cow. He mistook the transinsular fissure for the Sylvian.

In the insula of the cow, individual and lateral variations are perhaps more marked than in that of any other animal examined. We have here exemplified also the peculiar folded appearance first noticed in the bear but more marked.

The area representing the insula in the burro (*Equus asinus*) is better developed than that in the deer. It is well rounded and, except at two points along the cephalic boundary, the area is sharply defined by the circuminsular fissure (Fig. 24). As in the deer, the area is divided into a preinsula and a postinsula by the transinsular fissure, the latter area containing but one, while the former consists of four gyres all well developed and sharply defined. There is no approximation to a pole as in man. The location of the area is similar to that of the deer, only the caudal one third lying in the Sylvian fissure. The two most cephalic gyres of the preinsula were exposed before dissection and the plane of the area makes an angle of not more than 60° with that of the lateral surface.

In 1871, Lussana and Lemoigne (**33**) stated that the insula of the horse was of considerable size. The writer has examined five brains, two of which, at least, are worthy of description. The first was that of a work-horse (2777, R. half) which showed five gyres exposed previous to dissection. Upon dissection the plane appeared almost perpendicular to the lateral surface, the gyres were six in number and the fifth (from the cephalic end) was subdivided by a small fissure at the mesal end. The fissure separating gyres 2 and 3 is deep, extends over the dorsal surface and almost completely divides the preinsula upon the lateral surface.

The insulas of the "Sage horse" (Fig. 25) consist of five gyres each, of which three belong to the preinsula and two to the postinsula. Before dissection the left insula showed four gyres exposed while the right showed three. One of the main branches of the medicerebral artery lies in what I have called the transinsular fissure (Fig. 25). This fissure is well marked on both sides. In the left insula the two most cephalic gyres are nearly perpendicular, while the other three are at an angle of about 60° to the lateral surface. On the right all the gyres are in about the same plane which lies nearly perpendicular to the lateral aspect. Those of the postinsular seem better developed and the first gyre of the postinsula is the one most elevated. There seems to be an approximation to a pole in this specimen not found in any other animals than the primates. The second gyre is also the smallest as in man.

The insular region of the tapir (*Tapirus malayanus*, Fig. 31) presents a very peculiar appearance, from the fact that between the area which I have called the insula and the rhinal fissure there seems to have arisen a corrugated area which is not believed to belong to the insula at all. This area extends from the frontal to the extreme end of the occipital lobe and throughout its course lies just dorsad of the rhinal fissure which is interrupted at several points on the left side but is continuous on the right. The fissure dorsad of this area is nearly parallel to the rhinal except near the caudal end. The area included between these two fissures is fissured, but only slightly elevated above the olfactory tract, and is continuous with the insular area. The insula in this specimen is only slightly elevated and contains but two gyres of which the more cephalic is the larger. The fissures are simple and very shallow except the circuminsular at the cephalic end. The transinsular is not well marked near the mesal margin. The insula is entirely concealed.

In 1878 Krueg (**30**, 325) said the insula was present in the Hippopotamidæ. Chapman in 1881 (**9**, 144) said: "The

Sylvian fissure in my Hippopotamus is quite evident and within it I noticed a rudimentary island of Reil."

THE INSULA IN THE CETACEA.

Fig. 35 represents the insula of the porpoise (*Globiocephalus melas*). In this specimen the insula is completely concealed within the Sylvian fissure and the plane is parallel to the lateral surface. The area is proportionally very large but at the same time very flat and there is no evidence of a fissure homologous with the transinsular and no approximation to a pole. This specimen shows at least nine gyres, three of which are subdivided by fissures which are deepest near the circuminsular. It is not known that any of the fissures of this area are constant. In 1879 Spitzka (**53**) says the "insula in the porpoise has four times as many convolutions and is twice as large as that in man and is completely covered by the operculum and temporal lobe." The same author also says that one specimen in his posssession has either thirteen or fifteen gyres. Wilder [lecture] said that the gyres of the porpoise insula exceed in number those of any other mammal observed by him, but they are smaller, and he concluded that "in combined elevation and fissuration, the insula reaches its highest development in man."

Ziehen (**31**, 110, 1889) says of the white whale (*Beluga lucas*), "The area between the fissura circularis interna and the fissura circularis externa, probably also a large part of the covered portion of the floor of the Sylvian fossa ought to be designated as insula." Of the Sylvian fissure in *Megaptera boops*, he (**31**, 125) says "Ursprung vom aus der Fissura Rhinalis Anterior. Die Haupttheil bildet die obere Begrenzung des Inseldreiecks."

None of the representatives examined of the remaining orders show any evidence of an insula.

SUMMARY.

1. Neither the insula nor the claustrum is constant among mammals.

2. The insula is present in the Primates, Carnivora, Proboscidia, Ungulata and Cetacea. It is apparently absent in the Cheiroptera, Insectivora, Rodentia, Sirenia, Marsupialia and Monotremata.

3. The claustrum may include parts of areas other than the insula.

4. The insula and the claustrum may generally be considered as parts of the same cortical area; the claustrum may be present without the insula; both may be present or both may be absent.

5. The apparent absence of the claustrum when the insula is present indicates that, relative to the surrounding areas, the insular cortex is farther laterad than in those specimens where it is so demarcated. The myelinic fibers of the surrounding areas then pass wholly entad of the insular cortex.

6. The insula is, in general, a convoluted area.

7. The insula is sometimes a *subarea* but quite often it is exposed upon the lateral surface of the cerebrum.

8. The exposure of the insula may indicate either its own excess or the deficiency of the overlapping adjacent parts.

9. The gyres of the overlapping areas are always intercalated with those of the insula.

10. Individual and lateral variations upon this area are numerous and marked and are probably due in part to growth in an enclosed space.

11. The insula in the Primates, the Carnivora, some of the Ungulata and Cetacea and perhaps others is a subarea or subgyres at the bottom of the Sylvian fissure.

12. The insula frequently is almost wholly within the Sylvian fossa. This condition is not believed to indicate in any way a different relation to the parts entad but rather a more uniform development of the insula and the surrounding areas so that no lateral overlapping has taken place and hence the ventral end of the Sylvian fissure remains unclosed as a fossa.

13. The insular area, in the more generalized types of mammals, at least, does not belong primarily to the rhinencephalon as held by Turner in regard to the human brain.

14. The fissured surface which is usually the dorsal in the raccoon, the deer, the burro, the horse, the pig, and the sheep, is homologous with what appears on the lateral surface of the insula of the Primates, most of the Carnivora and some others.

15. The variation in the plane of the fissured surface of the insula is probably due to some peculiarity in the development of the brain stem.

16. Fissures on the insula are less deep and more open than on the surrounding parts; this is probably due to growth under pressure of overlapping parts.

17. The lack of conformity between the Sylvian and transinsular fissures both in position and direction is probably due to the mechanical effect of growth in an enclosed space by which a displacement of the Sylvian has occurred.

18. The difference in the relative mass of the insula, its position, plane and relative development in the camel and deer is very much greater than might be expected in two animals so closely related.

19. The difference between the insula of the bear and the raccoon is very striking.

20. It is noteworthy that the cat (*F. domestica*) and ocelot (*F. pardalis*) and the lynx have no insula, while the panther (*F. concolor*) and the lion (*F. leo*) have a rudimentary one.

21. The overlapping of the insula in the human brain, and presumably in others, is not due to a cessation of growth of the insula but to the more rapid growth of the surrounding lobes and the rapid enlargement of the paracœles.

22. The apparent approximation to a pole in the horse is noteworthy.

23. The primitive insula, if such exists, is a somewhat elevated area of greater or less size surrounded by a circuminsular fissure and located in the Sylvian fossa or in the fissure if the fissure is continuous with the rhinal.

SYNONYMY—INSULA.

1. Central lobe.—The application of this term to the insula is objectionable on account of its more common use in connection with a lobe of the cerebellum and also because the adjective, central, is often applied to fissures and lobes topographically related to the central fissure (f. of Rolando).

2. Convolutions placed between the fissure of Sylvius and the corpus striatum (Vicq d'Azyr).

3. Circonvolutions supplementaires (Leuret and Gratiolet).
4. Entosylvian folds or tract (Owen).
5. Fifth lobe of the brain.
6. Gyri breves (Gall, Arnold).
7. Gyri operti.
8. Gyri unciformes (Eberstaller).
9. Ile.
10. Insel (Reil).
11. Insellappen.

12. Insula. This name takes precedence over all others, being the Latin form of "Insel," the name given by its first describer, Reil. The regular paronyms of insula as given by Wilder (**22**, 530-31) are English, insula; German, Insel; French, insulé; Italian. isola.

13. Insula de Reil.
14. Insula del Reil.
15. Insular lobe.
16. Insula Reilii.
17. Insula Sylvii (Mingazzini).
18. Intersylvian convolutions (Owen).
19. Intralobular gyri (Quain).
20. Island of Reil (English Authors).
21. Isola.
22. Limen insulæ.
23. Lobe central (see note under 1).
24. Lobe central de l'insula (see note under 1).
25. Lobe de l'insula de Reil (Broca).
26. Lobe intermediare.
27. Lobe moyen.
28. Lobettino centrale nel tipo pecorino (Tenchini and Negrini).
29. Lobo centrale (Gratiolet).
30. Lobo fondamentale (Lussana).
31. Lobo insulare (Lussana).
32. Lobule de l'insula.
33. Lobule du corps strié.
34. Lobule sous-sylvien (Broca).
35. Lobulo del corps striato.
36. Lobulo sotto-silvico (Tenchini and Negrini).
37. Lobulus centralis (see note under 1).
38. Lobulus corporis striati.
39. Lobulus fissuræ Sylvii.

40. Lobus caudicis (Burdach).
41. Lobus insulæ.
42. Lobus intermedius s. opertus.
43. Lobus opertus (Arnold).
44. Lobus retractus.
45. Median lobe.
46. Minor intersylvian convolutions (Owen).
47. Quinto lobo delle cervello.
48. Reil's island.
49. Stammlappen (Huschke).
50. Subsylvian fold (Owen).
51. Subsylvian lobe.
52. Subsylvian tract (Owen).
53. Versteckenlappen (Arnold).
54. Zwischenlappen (Arnold).

SYNONYMY—CLAUSTRUM.

1. Avant-mur.
2. Claustrum (Burdach).
3. External wall (Huguenin, Charcot).
4. Noyau rubané.
5. Nucleus tæniæformis (Arnold).
6. Rampart.
7. Rempart.
8. Vormauer.

SYNONYMY—TRANSINSULAR FISSURE.

1. Fissura interinsularis (Eberstaller).
2. Hauptfurche der Insel (Eberstaller).
3. Inselfurche (Eberstaller).
4. Le grand sillon de l'insula (Brissaud).
5. Sulcus centralis insulæ (Guldberg) 13.
6. Sulcus centralis Reilii (Turner).
7. Sulcus Insulæ (Eberstaller).
8. Transinsular fissure (Wilder).

SYNONYMY—CIRCUMINSULAR FISSURE.

1. Circuminsular fissure, (Wilder).
2. Fissura circularis.
3. Rigoles de l'insula (Broca).
4. Sulcus circularis Reilii (Schwalbe) 43.

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66. 1894. WILDER, BURT G. Exhibition of a Suicide's Brain, with two Pistol-ball Wounds. Remarks on its Fissural Anomalies. *Journ. of Nervous and Mental Disease*, December, 1-4.

EXPLANATION OF FIGURES.

With the exception of figures 1, 2, 3, 4, 5, 6, 7, 8, 12, 17, 18, 19, 20, 21, 25, 31 and 34, all the figures were produced as follows: The specimens were photographed natural size, with a vertical camera; from the photographs out-

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* The exact title of Reil's article is not known by the writer.

lines were traced also with the camera. Liability to distortion due to the enlargement of the parts of an uneven surface was materially reduced. Figures 1, 2, 3, 4, 5, 6. 7, 21, 25, 31, were photographed natural size and enlarged from photographs or figures as indicated, with an enlarging apparatus. Figures 8, 17, 18, 19, 20 and 34 were photographed as stated and traced from photographs. Fig. 12 was made from outlines traced from photographs of lateral views before and after dissection.

ABBREVIATIONS.

art.—artery.
circ. f.—circuminsular fissure.
cl.—claustrum.
fi. olf. tr.—myelinic fibres of olfactory tract.
in.—insula.
op.—operculum.
P.—Pole of the Insula.
postin.—postinsula.
p. op.—postoperculum.
prein.—preinsula.
Preop.—preoperculum.
rh. f.—rhinal fissure.
subop.—suboperculum.
Sy. f.—Sylvian fissure.
tr. f.—transinsular fissure.
z. f.—zygal fissure.
v. f.—vertical fissure.

DESCRIPTION OF FIGURES.

The numbers are the serial numbers of the Museum of Vertebrate Zoology of Cornell University.

PLATE IX.

Fig. 1. Lateral aspect of the left half of the brain of a human fetus, size and age unknown. 2278; x 1 (after Wilder, **63**, Fig, 4760).

Fig. 2. Ventral aspect of the left cerebrum of a human fœtus, size and age unknown. 1820; x 1 (after Wilder, **64**, Fig. 4782).

Fig. 3. Lateral aspect of right human insula, age and sex unknown, adult, 1805; x 1. The insula was exposed by cutting away the surrounding lobes down to the level of the circuminsular fissure, thus exposing the medicornu and hippocamp. The three eminençes 1, 2 and 3 belong to the postinsula. The fissure marked 4 is too sharply outlined near the ventral end. At the point indicated it is a mere vasal furrow and does not communicate with the Sylyian fissure ventrad.

Fig. 4. Lateral aspect of right human insula, age and sex unknown, young, 1823; x 1. This preparation shows the branches of the medicerebral artery as it divides over the surface of the insula. The largest branch lies in the transinsular fissure for about two thirds of the distance across the insula, then leaves this fissure and bends caudo-dorsad as if towards the Sylvian. There is also shown a tendency toward the demarcation of an eminence similar to that shown in Fig. 3.

Fig. 5. Dorso-lateral aspect of the right human insula, age 37 years, male, 376; x 1. A nearly normal insula except for the unusually elevated pole, *P.* The short furrow cephalad is represented too deep and too narrow.

Fig. 6. Caudal aspect of a transection of the left cerebrum of man, after Wilder (**64**, 4732). Shows the relation of the insula to the claustrum, the brain stem and operculums.

PLATE X.

Fig. 7. Lateral aspect of the right insula of chimpanzee, supposed age 4 years, female, 265; x 1. The operculums have been cut away.

Fig. 8. Lateral aspect of the right insula of a macaque monkey, age and sex unknown; x 1. The lateral portion of the cerebrum was removed to the level of the ventral half of the circuminsular fissure. The remainder of the insula was exposed by cutting a groove parallel with the Sylvian fissure.

Fig. 9. Lateral aspect of the left insula of a seal (*Phoca vitulina*); x 1. Operculums cut away. The black areas at the dorsal and ventral ends indicate broken surfaces where the parietes were removed, and are too black.

Fig. 10. Lateral aspect of the left insula of a panther (*Felis concolor*), female, 18 years old, 309; x 1. Operculums cut away.

Fig. 11. Lateral aspect of the right insula of an adult raccoon (*Procyon lotor*), male, age unknown, 2031; x 1. The overlapping portions have been removed.

Fig. 12. Diagram of the same, showing the relation of the Sylvian and transinsular fissures.

Fig. 13. Lateral aspect of the right insula of a Thibet bear (*Ursus thibetianus*), male, age at least 5 years; 645; x 1. Shows well the relation of the transinsular and Sylvian fissures.

Fig. 14. Lateral aspect of insular region of a dog (cross between French poodle and Skye terrier), age more than 18 years, sex unknown, 166; x 1. Shows the exposure of the insula before dissection.

Fig. 15. Lateral aspect of the insula of the same with the operculums cut away; x 1½.

Fig. 16. Lateral aspect of the right insula of a dog (*Canis familiaris*), age unknown, probably adult, male; x 1.

Fig. 17. Outline of a section of the above looking dorsad; x 1. The dotted brace indicates the extent of the insula.

PLATE XI.

Fig. 18. Transection of the cerebrum of a dog (*C. familiaris*), male, age a few weeks, 3124; x 2½. Section made according to Weigert's method, after hardening the brain in 3% and 5% bichromate of potassium, imbedded in collodion and cut in oil; differentiates alba and cinerea.

Fig. 19. Transection (Weigert) of a portion of the left cerebrum across the Sylvian fissure of a cat (*Felis domestica*), age and sex unknown; x 2½.

Fig. 20. Transection (Weigert) of a portion of the right cerebrum across the Sylvian fissure of a skunk (*Mephitis mephitica*), age and sex unknown; x 2½.

Fig. 34. Transection of the right insular region of a sheep (*Ovis aries*), age and sex unknown, looking cephalad; x 4½.

PLATE XII.

Fig. 21. Lateral aspect of the left insula of an elephant (*Elephas indicus*), age unknown, female, 2181; x 1. Overlapping portions have been dissected away.

Fig. 22. Lateral aspect of insula of a camel (*Camelus dromedarius*), male, age 15 minutes, 2122; x 1. The shaded portion at the right of the insular area is a broken surface and does not belong with the insula.

Fig. 23. Lateral aspect of the left insula of a deer (*Cariacus virginiana*), male, age unknown, 961; x 1.

Fig. 24. Lateral aspect of the left insula of a Mexican burro (*Equus asinus*), male, age unknown, 2259; x 1.

Fig. 25. Lateral aspect of the left insula of a horse (*Equus caballus*), male, adult, 2095; x 1.

Fig. 26. Lateral aspect of the left insular region of a cow (*Bos taurus*), adult, sex unknown, 3408; x 1. Shows exposure of the insula.

Fig. 27. Lateral aspect of the right insular region of a cow (*Bos taurus*) adult, sex unknown, 3408; x 1. Shows exposure of insula before dissection.

Fig. 28. Dorso-lateral aspect of the right insula of the same, exposed by cutting away the operculums.

PLATE XIII.

Fig. 29. Dorso-lateral aspect of the left insula of the same after dissection.

Fig. 30. Lateral aspect of the cephalic half of the left cerebrum of a cow (*Bos taurus*), after Turner (**61**, Fig. 26). The fissure marked *S*, which Turner considers as the Sylvian, is the transinsular; the Sylvian is directly dorsad.

Fig. 31. Lateral aspect of the left cerebrum of a Malayan tapir (*Tapirus malayanus*), age and sex unknown, 2123; x 1. Dorsal portion of the cerebrum not shown; insula exposed by removal of overlapping parts.

Fig. 32. Lateral aspect of the left cerebrum of a sheep (*Ovis aries*), sex and age unknown, probably young; x 1. Shows the insula exposed before dissection.

Fig. 33. Dorso-lateral aspect of the right insula of a sheep (*Ovis aries*), sex unknown, probably young; x 1. Insula exposed by cutting away dorsal overlapping portions.

Fig. 34. See description under Plate XI.

Fig. 35. Lateral aspect of the insula of a Porpoise (*Globicocephalus melas*), female, adult, 670; x 1. Insula exposed by cutting away of the operculums. *Sy. f.* designates the basisylvian fissure between the temporal and frontal lobes.

REVIEW OF THE GOLGI METHOD.

By Oliver S. Strong.

The advent of the Golgi method in nerve histology has so greatly enlarged our knowledge and altered our conceptions of the structure of the nervous system in many respects and the method, or methods, itself has such well defined peculiarities that it has been thought that a general review of it from the technical side would be of interest and perhaps of use, especially in view of the very considerable number of investigators now employing it.

The review does not aim at any originality of treatment but is simply a compilation from available literature of its various modifications and applications. It may be stated that it does not include Golgi's arsenic-gold chloride method nor even the application of the bichromate-silver methods to the structure of medullated nerve fibres.

It has seemed most appropriate to begin the review with a translation of the technique of Golgi's methods as given by Golgi himself, principally in his work "Studi sulla fina anatomia degli organi centrali del sistema nervoso," pp. 181-208. The translation is made, however, from the German edition of Golgi's works (" Untersuchungen über den feineren Bau des centralen und peripherischen Nervensystems," pp. 169-182, translated by R. Teuscher). Golgi's own account of the technique is still the most complete nor does it seem to be by any means universally understood how completely Golgi worked it out and how largely we owe not only the discovery but also the development of the method to him. It is for these reasons as well as for the many valuable hints contained therein that the translation of this rather extensive account of Golgi's is here given.

"The particular methods to which I owe my most noteworthy success are the following: (1) The method of black-staining by successively treating the pieces (of brain tissue) with bichromate of potassium or ammonium and silver nitrate. (2) The method of the successive action of a mixture of osmic acid and bichromate and of silver nitrate. (3) The method of the combined action of bichromate of potassium or ammonium and bichloride of mercury. (The stain appears black by transmitted, metallic white by reflected light).

"(1) *The method of the combined action of bichromate of potassium and of silver nitrate.* In the series of methods which I have especially employed this is, in a manner, the fundamental one. The others are only variations of this, devised to shorten the time of the preliminary treatment, to make the preparations more stable, to vary the results in various ways, especially to obtain a greater extension of the reaction and to cause the reaction to affect one or another species of the elements or a part of them.

"I consider it to the point to call attention to the fact that the procedure of the microscopical technique which I will describe, although it rests essentially upon the action of silver nitrate, has nothing in common with the usual method of staining the intercellular substance of endothelium, epithelium and connective tissue brown or black. In the latter method dilute solutions of silver nitrate are applied immediately to the fresh tissue, exclusively to the surface of membranes or membranous tissues of slight thickness (aponeurotic plates, substance of the cornea, intima of vessels) and light exerts an important influence upon the reaction whereby the blackening of the combination which the silver salt forms with the ground substance is brought about. With my method the light has nothing to do and the reaction takes place through the gradual penetration of the silver salt into more or less voluminous pieces which have been previously treated with bichromate. The black-staining of the various elements composing the nervous tissue results from a reducing action which the elements themselves exert, under the influence of the bichromate, upon the silver salt.

"The procedure necessary to bring about the black-staining of the elements of the central nervous system consists essentially of two parts.

"(*a*) *Hardening of pieces in a solution of potassium bichromate.*

"(*b*) *Immersion of the hardened pieces in a solution of silver nitrate.*

"(*a*) *Hardening in bichromate.* Although there are no especial rules for the hardening other than those which must usually be followed to obtain a good uniform hardening, yet it is this part of the process which requires the most care. This is the more so because the time necessary to harden the pieces to the degree required for the action of the second reagent varies very considerably according to different circumstances and especially according to the temperature.

"For the first immersion of the pieces, I use either a simple two per cent. solution of potassium bichromate or the usual formula of Müller. (The reagents should be pure.) There must be an abundant quantity of fluid in proportion to the quantity of pieces to be hardened.

"The part of the brain or spinal cord to be treated is cut into tolerably small pieces (about 1 to 1½ ccm.). It is important that the pieces be fresh; the fresher the pieces, the better the results. It is well to use, preferably, the brains of animals just killed, yet satisfactory results can also be obtained 24 to 48 hours after death. It is hardly necessary to say that the pieces must be cut regularly and in definite directions (according to the part to be studied) so as to permit orientation as to the part and the location of the elements in the future study.

"That the hardening may proceed with some rapidity and be uniform, it is well to successively increase the concentration of the fluid, raising the quantity of bichromate from 2% to 2½, 3, 4 and 5%.

"Whether the fluid is increased in strength in hardening the pieces, or remains the same strength, it is always necessary to change it from time to time to avoid the formation of moulds which, as is well known, develop abundantly in bichromate solution when the pieces are to some extent neglected. For the same reason it is advantageous to place in the vessels with the pieces a small quantity of some substance which will prevent the growth of hyphomycetes, as camphor, salicylic acid, etc. The most important point and at the same time the most difficult to determine in order to obtain good results with this method is the length of time during which the pieces must be kept in the bichromate solution before one passes on to the second part of the process, the reaction with the silver nitrate.

"The proper duration of immersion for the pieces to obtain that degree or particular kind of hardening which is best fitted to secure, when they are laid in the silver solution, a fine and diffused action upon the various elements of the nervous system varies according to various conditions. These are the strength of the fluid, the condition of the pieces, the quantity of fluid, temperature and, consequently, the time of the year.

"The differences arising from the strength and quantity of the fluid may be eliminated by paying strict attention to the strength of the fluid, by using covered vessels and preserving the same ratio between the number of pieces and quantity of fluid.

"The influence of temperature upon the results of the reaction is more important, indeed practically all the uncertainties of the method depend upon this. For example, to mention extremes, good results (which, with the progressive changes, of which I shall speak later, continue to appear and extend) can be obtained in the warm season after an immersion of 15 to 20 days and seldom after 30 to 40 or 50 days; on the other hand in the cold season good results are scarcely obtainable after an immersion in bichromate of less than 1 to 1½ months. The reaction (with the progressive accompanying changes) may then continue to manifest itself for 2, 3 or 4 months, provided, of course, the pieces are preserved according to the rules given above. It is almost superfluous to say that during the gradual change from the warm to the cold season and *vice versa* corresponding changes in the appearance of the reaction take place. It is not easy to remedy these temperature changes, especially because these changes of environment are united with the other causes of uncertainty mentioned and so act that observations made upon one series of pieces, never agree closely with those made upon another series. A warm chamber, of which I shall speak later, cannot bring about the accuracy sought for.

"The surest means of remedying these inconveniences is the persevering repetition of the process, i. e. one must have a good number of pieces available, bring several from time to time into the silver solution and then ascertain whether they are in the desired condition. If a good reaction has taken place, one continues the trials at regular intervals in order to obtain all the stages of the reaction, which constitute an advantage of this method. It is self-evident that the different trials must follow each other at intervals differing according to the time of the year. In the warm season, when the requisite hardening is reached much earlier, the trials must follow each other more quickly; in the cold season, on the other hand, when the desired hardening is first reached after a month, the trials can be made at intervals of 8 to 10 days beginning with the time when one, according to my direction, has ground to assume that the tissue has begun to enter the desired condition.

"(*b*) *Transference of the hardened pieces into the solution of silver nitrate.* Although the various conditions of which I have spoken make it impossible to state with complete accuracy for how many weeks or days the pieces must be brought from the bichromate into the solution of silver, this is no ground for concluding that the method is subject to excessive uncertainty. All difficulties are overcome and one can be absolutely sure of always obtaining excellent results by the simple procedure of steadily extending the trials with every series of pieces. The difficulties are thus very like those which one encounters in the employment of all other impregnation and imbibition processes, not excepting the simple carmine staining, in which, as is well known, one only reaches quick and certain results after repeated trials when he has learned to know the nature of the staining fluid and of the pieces to be stained.

"I usually employ a ¾% silver solution; yet I will remark that it is not necessary to adhere closely to this formula to obtain the reaction. A slightly stronger or weaker solution does not affect the result. I will also add that a slightly weaker so lution (½%) appears to be somewhat more suitable (giving finer results though confined to fewer elements) so long as the pieces have not yet reached the complete hardening, while a slightly stronger solution (to 1%) appears better adapted for pieces whose hardening has progressed a little too far.

"The quantity of the silver solution to be used must vary with the number and size of the pieces to be laid therein, but must be relatively abundant. For two or three pieces of about 1 ccm. I use about half a beaker (*bicchiere*) of the fluid.

"The moment the pieces are brought from the bichromate into the silver solution a copious yellowish precipitate of silver chromate results. The formation of this precipitate takes place, of course, at the expense of the strength of the fluid inasmuch as through the formation *in loco* of the insoluble precipitate a more or less considerable portion of the silver salt is deposited. This changes, naturally, the relation (osmotic as well) between the fluid which should penetrate into the piece and the inner portions of the piece. It might happen that the whole or the greatest part of the silver would be precipitated from the solution, which would result in the more or less complete absence of the reaction. To avoid this mishap it is expedient to first wash the pieces in which the reaction is sought in a weaker solution of silver. I use for this purpose, from motives of economy, silver solutions which have already been used on other pieces without the silver having been fully neutralized. When this washing has been continued until the pieces cause no more precipitate when brought into a clear solution[1] they are finally placed in the fluid of the proper strength. From there on the preparation usually requires no especial attention, for if the solution is present in copious quantity it is sufficient to let the fluid penetrate into the interior of the piece. Yet it is well to consider that it is sometimes expedient, with pieces thoroughly saturated with bichromate through a long sojourn therein to

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[1] Several minutes should elapse to test this, inasmuch as the discoloration of the silver solution by the reddish precipitate sometimes takes place rather slowly, both in this and in the rapid method.—*Writer.*

change the solution for a fresh one after the pieces have been in the first solution 6 to 8 hours. This must be done whenever the fluid assumes a yellow color, which shows that the silver nitrate is neutralized. In this case the reagent can no longer possess the necessary strength to penetrate to the interior of the pieces.

"I have already said that this reaction, through which the black staining of the elements is brought about, has nothing in common with that which stains the intercellular substance under the influence of light. I now need to add that it is entirely the same whether the pieces in our method are kept in the light or in the dark; the reaction which is brought about through the gradual penetration of the silver into the interior of the tissue takes place equally well in both cases. The only rule relating to keeping the pieces in the silver which experience has shown to be in some manner useful is that they should be kept in winter in a well-heated room. I place the vessel on a table which is not far from the stove of the laboratory.

"The pieces must remain, as a rule, in the silver solution for 24 to 30 hours, in exceptionable cases 48 hours. The period of 24 to 30 hours must form the rule although, when the time of hardening has been correctly hit upon, the reaction may be well advanced in 2 to 3 hours. In such cases one may say that the reaction begins immediately, at least in the superficial layers, to extend gradually deeper with the deeper penetration of the fluid. In the exceptional cases when it is best to leave the pieces 48 hours and longer in the nitrate solution and where it is well to change the solution a second time, one must regulate his procedure by the results of a microscopal examination of some superficial sections from which the condition of the reaction may be inferred. Moreover one can perceive from the yellowing of the fluid, whether the reagent is nearly neutralized.

"As for the rest, it is to be remarked that an indefinite sojourn of the pieces in the silver solution lasting days, weeks or even months is in no way injurious to them; on the contrary this is a suitable means of preservation for pieces destined for a particular investigation of long duration.

"One of the most interesting peculiarities of the process which I here describe consists in the fact that, while the brownish black stain acts quite similarly upon all elements of the nervous tissue (various kinds of ganglion cells, nerve-fibers, elements of the neuroglia and walls of vessels), yet in reality the staining of all these at one time forms an exception, i.e. when the elements are in a certain state of hardening which one only happens upon accidentally in a great number of trials. As a rule the reaction appears only partially, i.e. it affects only one or another layer with gradations and combinations which one may term endless.

"This peculiarity does not detract from the method, but is rather among its advantages, for if the reaction affected all kinds of elements at the same time there would evidently arise such an inextricable confusion that it would be impossible to orient oneself in respect to the locations and relations of the individual parts. When, for example, in one preparation the the cells especially are stained black, in another principally the neuroglia together with the vessels and some groups of nerve cells, it is evident that one can by the comparison of many preparations obtain a general view of the various peculiarities of the arrangement and relations to each other of the individual species of elements and of the connection of the structures of various regions.

"This is so much the more the case since these combinations and gradations also appear in certain layers and different zones into which one is accustomed to divide different regions of the nervous system. In the cortex, for example, the reaction appears, with the various combinations above mentioned, sometimes in the superficial or middle, sometimes in the deep layers.

"A law undoubtedly exists governing the manner of development of the black stain and the succession of the reaction among the various kinds of elements and it would be interesting to learn to know this so as to be able to bring about one or another result at will; but it is extremely difficult, if not impossible, to attain this. This difficulty will be readily comprehended when one reflects that the diversity of results is brought about not only by the conditions given already but also by the unequal hardening action of the bichromate so that the individual layers of the pieces are in different conditions. In the individual pieces the degree of hardening may increase from center to periphery so that a number of the above combinations and gradations may appear in one piece.

"The following approximate rule, however, may be accepted for the way the reaction enters the various elements of the nervous tissue when a number of similar pieces are successively subjected to the action of the silver nitrate. There stain in the following order:

"1. *The bundles of nerve fibers.* At the same time with the staining of these fibers some scattered ganglion cells which lie dispersed in the gray matter appear.

"The staining of the nerve fibers at the beginning shows little delicacy, the reaction being, so to speak, tumultuous, but gradually gains in fineness with progressive hardening (always, however, after a more or less brief period of time). Then the individual fibers (axis-cylinders) composing the bundles can be well seen and also individual fibrillae streaming from the bundles, the finest details of whose course and branching can be seen at a glance.

"2. *The ganglion cells.* The ganglion cells of the superficial layers always stain first (e. g. in the cortex the small cells of the peripheral zone), but at the same time with them also some cells irregularly scattered in the inner layers. As the reaction progresses it affects the cells rather than the fibers and the tendency is for the stain of the cells to become more general and to extend from the periphery inwards. Then, too, while the reaction is becoming more complete among the cells of the deeper layers it becomes always more limited among those of the superficial layers.

"With the cells as with the fibers the reaction is at first coarse and little fitted to bring to view certain interesting details. For example, the nervous process is not stained at first to any great extent and usually only a short piece of it is to be seen so that neither its course, direction nor its few or numerous branches can be perceived. With the gradual progress of the reaction the nerve cells are displayed more clearly and the finest subdivisions of their protoplasmic as well as their nervous processes appear.

"3. *Cells of the neuroglia.* An interesting reaction occurs in the cells of the neuroglia; it may be said that it takes place in pieces suitably hardened in bichromate from the beginning of the phase to the end. In fact at both the time when the fibers predominate and when the cells predominate individual neuroglia cells or groups of them are to be seen showing the characteristic reaction of the silver nitrate (coffee-brown or yellowish). Besides, with this species of element the reaction only becomes fine and diffused in a somewhat advanced period of hardening so that their typical form and relations are plain. The reaction in neuroglia cells takes place for a long time beyond the time favorable for staining nerve cells.

The finest reaction for the nerve cells, especially for the nervous processes, occurs at a somewhat advanced stage of hardening, namely when, with the advance of the reaction among neuroglia cells, it is limited among the ganglion cells. It is precisely among isolated blackened cells that the stain of the individual functional (axis-cylinder) processes is finest; one can observe the smallest details of their course and branching. I must again recall that the reaction must be produced in a series of pieces which have consecutively received suitable treatment in order to learn to know all its phases.

"After we have so circumstantially laid down the fundamental rules of procedure, it would be superfluous to go into particulars about the differences obtaining between the different provinces of the central nervous system (the cortex cerebri, the so-called ganglia of the base, the cerebellum, the spinal cord). I only remark here that, under similar conditions, pieces from the cortex reach in bichromate the suitable state of hardening somewhat sooner that than those from the cerebellar laminae, that the latter reach it a little later than pieces of the spinal cord and that finally the so-called ganglia of the stem reach the proper hardening still somewhat later than the parts named.

"A last remark. When the above-described peculiarities of the process are considered, it is intelligible how it often happens that the reaction appears only in one part of the piece. For example, it is absent in the superficial layers, where there is, as a matter of fact, more often than otherwise only an irregular precipitate, and is present in the interior or *vice versa.* One must remember this and when, very likely, the first sections made near the surface show nothing of interest one must not thereupon conclude that the reaction has failed, for it often happens that such preparations, in which only single, isolated cells are stained, are among the most instructive for details of the individual elements.

"*Treatment and Preservation of Preparations.* Whether the black stain has turned out so that the piece is worth keeping for further investigation can be ascertained by means of trial sections examined in glycerine or in the reaction fluid itself. Then one must provide for the preservation of the piece and the microscopical sections. Although it is certain that a longer sojourn in the silver solution does no harm whatever and that such a sojourn may serve as a means of preservation, yet is expedidient, in order to have the pieces ready for further treatment, to transfer them to pure commercial alcohol. This not only serves to harden the tissue farther but also to free it from the silver nitrate which, as I shall mention below, is very injurious to the preservation of the microscopical sections. To accomplish the latter the alchol should be changed two or three times till it remains transparent for a number of days after the piece is brought into it. In this way the pieces can be kept a long time. I have kept them for about nine years in this way and can obtain from them, when I wish, preparations as clear as those obtained from them shortly after their preparation.

"The further treatment of the microscopical sections corresponds essentially with the usual procedure in obtaining anhydrous preparations except for some peculiarities necessary to overcome some difficulties in the way of securing stable preparations.

"The sections, before they are permanently brought into gum damar or Canada balsam, must first be treated successively, according to the classical method, with absolute alcohol and some clearing fluid. Each of these steps requires an especial care not necessary with ordinary preparations.

"(*a*) *Treatment with absolute alcohol.* The only rule to be especially noticed here is that the sections must be very carefully dehydrated by bringing them into three or four changes of pure absolute alcohol. This is the only principal rule in order to obtain a long preservation, for the more accurately and carefully the dehydration is carried out, thereby freeing the tissue from the last trace of silver nitrate, the more one can rely upon the preparations remaining clear a long time.

"(*b*) *Clearing.* The sections to be mounted must first be brought, for clearing, from absolute alcohol into creosote, where they remain some minutes, and then into turpentine. In the latter they can remain a long while. The selection of these two substances and their consecutive use is another aid to securing a long preservation. Among many other substances tried for clearing I have also found oleum origani[1] for my method very useful, but I have found no sufficient ground for abandoning the first mentioned fluids. The sections usually remain in turpentine only 10 to 15 minutes but may remain there longer.

"(*c*) *Completion of the microscopical preparations.* For permanent preservation the sections are brought from turpentine into damar which, after many comparative tests, I have found better adapted for this purpose than Canada balsam. I must here call attention especially to a peculiar treatment of the sections; contrary to the usual custom, I do not cover the preparations with a cover glass. When the sections are covered in the usual way with a cover glass, they begin after a time to turn

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[1] This oil, followed by washing in xylol instead of turpentine, is preferred by the writer.

yellow (owing to a second impregnation which takes place), then the outline of the stained cell elements become obliterated, the whole tissue becomes opaque and, after a period of from two or three months to two years, the preparations, with few exceptions, become useless. On the contrary they may keep a long time thanks to the repeated washing, of which I have spoken, and especially to the mode of mounting without a cover slip in a layer of damar. I can now state that the earlier lamentable disadvantage that preparations made by my method soon spoiled is now almost completely remedied. I have many preparations made by me nine years ago which have not yet lost their original clearness.

"If the good preservation appears menaced by an incipient yellowing, another longer bath, on the slide, in turpentine will restore transparency and freshness to the preparation.

"I have found it convenient to employ for this kind of mounting a special wooden slide with a square opening in which, by means of a groove, a glass plate (a cover slip of somewhat greater diameter than usual) is fitted and stuck fast with a solution of shellac in alcohol. This serves as a slide and the section adheres to it by means of the damar.

"This kind of slide not only enables the section to be examined from both sides but also has the advantage of preventing dust from fouling the object, to which this kind of mount would be especially exposed. To accomplish this it is only necessary to turn the side of the slide with the section downwards as soon as the damar is hard enough, or to pile the preparations on top of each other.

"I further remark that it is wise to shield the objects from the influence of light ; still this precaution is not entirely necessary if the repeated washing has been carefully performed. After fulfilling these conditions, I might expose preparations for days to the sun's rays without injury to them.

"This is not the place to lay stress upon the value of the results which can be attained by means of this method. The figures accompanying this work demonstrate it sufficiently. They display the forms to be observed in the preparations with a fineness not only not exaggerated but inferior to the natural object. I will here only bring forward the disadvantages of the method, in order to give the means by which they are to be avoided. The long time between the placing of the pieces in bichromate and the appearance of the reaction (it not infrequently happens that in consequence of this the pieces are forgotten), the uncertainty about the extremely variable time required to reach the proper hardening, the different conditions in which individual layers of the same piece are found, all these are disadvantages whose removal would be desirable.

"I have sought by expedients to change my method in one way or another in order to secure greater certainty and accuracy in the results. Among the means tried by me I present the following which have yielded me a certain advantage.

"(*a*) *Injections of bichromate* (solution to 2½%.)[1] It must be abundantly and constantly applied so that the whole parenchyma of the part to be investigated is fully and uniformly penetrated by the hardening fluid. The fixation of the elements by the reagent, where possible, before the slightest post mortem change can take place is of the highest importance in securing a very delicate reaction. The action of the injection consists principally in giving a uniform hardening, furthermore in preventing, very likely, a slight post mortem change in the interior of the piece and finally in abbreviating the sojourn in bichromate.

"If I may draw a conclusion from some especially successful reactions accomplished in this way, I must declare that the injection is in these various respects actually of considerable advantage. Some other experiments, not yet very extended, have convinced me that a favorable influence is exerted in the same way by injecting, not a simple solution of bichromate, but one with gelatine added (2½% bichromate, 100 cc.; dry gelatine, which is dissolved in the usual way, 5 to 6 grams). This procedure appears to me especially fitted to give the

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[1] A stronger solution would probably be better, inasmuch as it undergoes dilution in the tissue.—*Writer.*

pieces in less time that particular hardening most favorable to the best reaction with silver nitrate. I mention, for example, a case where I have obtained graduated reactions of surprising fineness on pieces 15 to 30 days after they were placed in bichromate at a temperature of 15° to 20° C. (in autumn), the pieces having been subjected to the above treatment.

"The injection is performed in the usual way (with a simple syringe or with a siphon in which the pressure is regulated by the height of the vessel containing the injection fluid) either through the carotid, when one wishes to limit the hardening to the cerebrum and cerebellum, or through the aorta when the fiuid should also extend to the spinal cord.

"It is superfluous to state that when the bichromate and gelatine is injected it must be warmed so that it will remain fluid. In this case it is especially important to perform the operation immediately after the death of the animal, before the tissues are cold. Only in this way does one secure the finest and most widespread injection.

"After the injection the nervous parts are removed from their cavities, cut into pieces and brought as usual into bichromate where they are carefully treated as dealt with above.

"(*b*) *Hardening in bichromate at a constant temperature.* The circumstance, pointed out several times, that the uncertainty about the time at which the pieces must be brought from the bichromate into the silver solution depends for the greater part upon the temperature of the medium leads to the idea that the best means of avoiding this inconvenience would be the employment of a constant temperature for the bichromate in which the pieces lie. For this purpose the warm chambers used in investigations upon micro-organisms seem best adapted.

"I have used the chamber of Wiesnegg in which I maintained a temperature of 20° to 25°. This had good success but only in the direction of considerably abbreviating the period of hardening in bichromate so that the reaction could be obtained much sooner than formerly and in a tolerably constant period of time. Thus the reaction in the warm chamber appeared after 8 to 10 days and proceeded to completion up to 15 to 20 days. This is, perhaps, an advantage in so far as one can with sureness obtain certain preparations for demonstrations in a tolerably brief time. But the advantage is not extended to the fineness of the result since in all such preparations the reaction turns out rather coarse. I was not thereby encouraged to extend experiments in this direction, especially as the abbreviation of the time can be attained in other simpler ways and as the pieces in the chamber quickly pass by the period favorable to the success of the reaction without attaining the kind of hardening sought—which is a not insignificant disadvantage.

"(*c*) *Hardening in Erlicki's fluid* (bichromate of potassium, 2½ g.; copper sulphate, ½ g.; distilled water, 100 g.). Regarding this I confine myself to stating that the copper salt added to the bichromate did not prevent the reaction and that the Erlicki's fluid possessed the same advantages and disadvantages as the preceding method (warm chamber). It accelerates the hardening so that in a few days (6 to 8 to 10) the black stain of various elements of the nervous system can be obtained by transferring to silver, but the result cannot be commended for fineness. Moreover the period advantageous for the reaction is very quickly passed over.

"As it appeared to me that the limited and not very fine form of the reaction might be due in part to the rapid action of the hardening fluid, I weakened the same by mixing it in gradually increasing quatities with Müller's fluid (Erlicki 20% to 50%, Müller 80% to 50%). The results obtained by means of this variation were decidedly good. After only 5 to 6 to 8 days immersion in such a fluid I obtained preparations which in regard to fineness of result had a certain worth. It thus appears to me that this variation can be recommended for the purpose of quick demonstrations of cell-forms. For the finest details, especially the relation of the functional processes of the ganglion cells and the nerve fibers, I find that the first procedure is always to be preferred, or also the following:

"2. *Method of the successive actions of a mixture of osmic acid with bichromate and of the silver nitrate.* This procedure also is only a modification of the original but deserves a place in the exposition as a method by itself, partly because the not unimportant changes of the results which it yields and the treatment which it requires are to be ascribed to the newly added reagent, partly because the process so modified can remedy some inconveniences of the original method.

"It can be applied in two ways, namely:

"(a) By laying small pieces of nervous tissue directly in a mixture of bichromate and osmic acid (2% to 2½% sol. of bichromate, 8 parts; 1% sol. of osmic acic, 2 parts).

"The black stain is obtained the most quickly with this procedure. The black staining of a great number of nervous elements can be obtained by transferring into silver at the second or third day (see the directions for procedure in the description of the original method). The reaction extends itself on the immediately following days, then, as usual, diminishes and at the tenth or twelfth day entirely ceases.

"The treatment of the macro- and microscopical preparations which are obtained in this way must be considerably modified. Pieces prepared by this method differ from those prepared by the first method inasmuch as when they are kept a long time for future use, they become diffusely blackened and thereby useless. They must be kept in the same silver solution which has served for the reaction. Then they are brought into pure alcohol, which must be changed, where they remain not longer than two days, sectioned and subjected to the above described treatment (absolute alcohol with repeated washing, creosote, turpentine, damar) necessary for their permanent preservation as microscopical preparations.

"Although this application of the osmium-bichromate solution is certain and, as far as fineness is concerned, yields satisfactory results; yet I find that for a systematic study of any definite portion of the nervous system the following method is far preferable:

"(b) *Bringing of fresh pieces into the bichromate solution; first transference into an osmium-bichromate solution; second transference into the silver solution.* It is different with this second procedure than with the preceding, in which the series of pieces of tissue to be examined are useless after a few days. Here the fresh pieces (with or without injection) are laid in the bichromate solution and remain, so to speak, in the hand of the investigator. They can either immediately or later be tried i. e. during a period of from 3 or 4 to 25 or 30 days after the immersion. If one during this whole period transfers at intervals of 2 to 3 or 4 days some pieces into the osmium-bichromate solution, he thus possesses many secondary series of pieces which are brought singly (1 or 2 at a time) into the nitrate solution. These, from the third or fourth to the eighth or tenth day of their sojourn in the mixture, yield with certainty, when brought into the silver, preparations with all the consecutive gradations and combinations described in the original method and also possessing surprising fineness.

"*After-treatment.* Preservation of the pieces in the silver solution; pure alcohol for 2 or 3 days, till one has time to undertake the examination; repeated washing out of the sections with absolute alcohol; cresote, turpentine, damar, mounting without cover glass.

"This is the method which I at present prefer for the demonstration of the finest details in the structure of the central nervous system. The particular grounds for this preference are the following: (1) Certainty of obtaining the reaction in many gradations, if one makes use of a certain number of pieces. (2) The considerable length of time during which one can obtain the reaction—while one can also attain it in a few days. This renders an accurate investigation much easier. (3) The pieces are much more conveniently treated. (4) Finally, one obtains at the same time with the gentle gradation of the results also a greater fineness of the same, especially regarding the behavior of the functional processes of the ganglion cells.

"3. *Method of the consecutive actions of the bichromate of potassium and of bichloride of mercury.* This can likewise yield valuable results whose value is not diminished because they in many respects conform to those obtained by the silver nitrate. Indeed, the particular purposes it can fulfil and its peculiar advantages are in and for themselves so important that it must be given a place of its own alongside the silver nitrate method. The clearness with which the various elements of the nervous system emerge in this reaction is not less than that brought about by the silver nitrate. The elements appear, when viewed under the microscope by transmitted light, completely black after the action of the sublimate and for microscopal investigation the action is the same as when there is an actual black stain. But this stain is only an appearance due to the opacity of the elements upon which, probably owing to a reducing action, the mercury has precipitated. In reflected light one notices that the elements appear entirely white, indeed under stronger magnification they show plainly a metallic luster.

"I will remark that the particular advantages of this method consist first in the fact that the reaction can take place in large pieces, further that its success is absolutely certain without being necessarily bound by strict rules as to the time of sojourn in the hardening fluid, and finally in the fact that the preparations which it yields require no especial precautions for their preparation, but can be treated in the usual way, like sections stained with carmine.

"The mode of application of the sublimate method is only distinguished from the silver method by some unessential things. It likewise consists of two essential processes:

"(a) Hardening of the pieces in bichromate.

"(b) Transference of the same into a solution of bichloride of mercury and sojourn in the latter.

"(a) The hardening in bichromate is done entirely in the usual way. (See the original method). I only add that the reaction does not proceed in an essentially different manner if consecutively stronger solutions of 1, 2, 3% are employed or if the pieces are immediately laid in Müller's fluid. In general it is expedient for the pieces to be small but this is not absolutely necessary. Good results are also obtained with large pieces, indeed with whole brains. In the latter case the preserving fluids require a long time to pentetrate by osmosis from the periphery into the interior and the central portions could spoil before they experienced the action of the fluid. It is necessary therefore to make a careful preliminary injection of bichromate solution so that the reagent is well distributed throughout the organ.

"A few days (6 to 8 or less) sojourn in the bichromate solution is sufficient to obtain, by putting the pieces into sublimate solution, an extended fine black stain of a greater or less number of cells (indeed one can obtain an indication of the reaction on the fresh brain which is placed immediately in the sublimate solution). A more suitable period to obtain fine and extended results is from 20 to 30 days. A much longer hardening (from 2, 3, 4 months or more) is by no means unfavorable for the reaction. I remember, among other cases, to have obtained reactions of wonderful fineness in some whole brains which were in bichromate solution nearly a whole year.

"It will be perceived that this indefiniteness of the time constitutes a very advantageous circumstance since thereby pieces can be employed which would otherwise be useless.

"(b) Transference of the pieces into the sublimate solution. The solution used by me contains ½% of bichloride of mercury. I have satisfied myself that the method is equally successful when the solution is weaker (¼%) or stronger (1%). The pieces are brought immediately from the bichromate into this solution.

"The reaction throughout the thickness of the piece results much more slowly than with the silver nitrate. If the pieces are suitably hardened, 24 to 48 hours suffices with the latter. With the sublimate, on the other hand, not less than 8 to 10 days are necessary, in order that the reagent may penetrate throughout the piece, when the pieces are small and much more (2 months and upwards) when the pieces are large (whole brains). The period of action of the bichromate must also be considered; the longer this has been, the longer must be the sojourn in the sublimate, but the more complete and delicate is the reaction.

"During the sojourn of the pieces in the sublimate solution, the bichromate with which the tissue is saturated diffuses out and impairs the purity of the fluid, which assumes a yellow color while the pieces become paler. For this reason the sublimate solution must be changed daily, especially at the beginning of the immersion. Later the changes are made only when the solution becomes yellow.

"It may be assumed that the reaction begins when the pieces are entirely decolorized, i. e. when the tissue is completely freed from bichromate. If, beginning about this time, sections are made and examined under the microscope daily, it will be noticed that the first traces of the reaction begin 3 or 4 days after the immersion and that they can be known by a number of small black spots scattered here and there. After 4 or 5 days more one sees the cell-forms gradually become more complete and numerous and the reaction thenceforward continues to extend and complete itself. It even appears that further advantages are gained when the sojourn in the sublimate solution is extended indefinitely, the sublimate being changed as often as it becomes yellow through the presence of bichromate. With brains which have been long exposed to the action of the bichromate,—and such often yield the most beautiful results,—the sublimate solution must be changed during several months before this yellowing ceases.

"The above constitutes a further difference from the manner of action of the silver nitrate, inasmuch as in the latter the whole action is completed in 24 to 48 hours, after which no further action is exerted, although the pieces can be kept in it longer.

"When the reaction has reached its maximum, the pieces remain colorless and have the appearance of fresh brain tissue which has been slightly washed in water.

"The pieces may remain in the sublimate solution as long as one pleases, not only on account of the possibility of a further extension of the reaction but also because they thereby receive a hardening better adapted for making fine sections.

"As to the manner in which the reaction extends to the different elements, I will merely remark that the reaction affects the ganglion cells in pieces which have reached that degree of hardening attained in the first month's immersion in bichromate and the reduction only extends itself gradually to the nerve fibers also. The reaction displays itself to the fullest extent in the nerve fibers almost exclusively in pieces which have lain a long time in bichromate and are very strongly hardened. I recall in this connection the brains which had been kept very nearly a year in bichromate: they showed an almost universal very fine stain of the bundles of nerve fibers and of their finest subdivision.

" *Treatment and preservation of microscopical preparations.* The only special precaution required by preparations made by means of the sublimate reaction before they are mounted in glycerine or balsam is a careful washing in water. Without this precaution a precipitate in the form of a black powder or needle-shaped crystals is formed in the sections some days after mounting and if it does not entirely spoil, yet seriously mars them. As to the rest, the usual mode of preparation is employed: mounting in glycerine, damar or Canada balsam after the necessary dehydration in absolute alcohol and clearing in creosote or clove oil. No further precaution is necessary.

"When I described this method the first time[1] I expressed the conviction that it could be still further perfected so as to yield finer results than those hitherto attained by me. Practice has later led me to some modifications which have improved it. But it has experienced another important development owing to the perservering experiments of Dr. Mondino who succeeded in applying the process with remarkable success to nothing less than a whole human brain. I will here add the words themselves in which this observer summarizes the advantages which one can gain from the use of the bichloride of mercury for the study of the central nervous system.

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[1] CAMILLO GOLGI. Di una nuova reazione apparentemente nera delle cellule nervose cerebrali ottenuta col bichluro di mercurio. *Archivio per le Sc. med.*. Vol. III.

"The following is Dr. Mondino's Summary:[1]

"'A. The sublimate method is the first by means of which we can obtain the black stain of the nerve cells and their functional processes in the entire brain and enables us to follow these latter directly in their course through the brain.

"'There is no doubt but that this technique fulfils the requirements of scientific accuracy better and puts us in a better position to obtain precise knowledge of the so much debated course of the fibers in the brain than all the methods hitherto tried. At the most one could only, with the aid of the latter, see whether numerous functional processes, collected into bundles, proceed in certain directions but with our technique one can examine them fiber by fiber and follow their anastomoses.

"'B. In all other methods we must, in order to obtain consecutive series of brain sections, bring the individual sections into vessels with the staining fluid. As one cannot provide so many vessels with fluid unless he possesses unusual means, sevral sections must be brought into one vessel and can therefore only be enumerated by groups and not singly. By the method here described this result can be attained with great ease.

"'C. In the other methods the sections must be very thin and are liable to be torn in the various manipulations (from the microtome into the staining fluid, then to the slide, etc). As the sections are very thin they must also be much more numerous when a whole brain is sectioned; hence greater expense, loss of time and more labor in making the preparations. In our method the sections need not be thin, they are therefore less numerous and exposed to fewer risks; whence little danger of losing sections, slight expense in the preparation and greater rapidity in the preparation of a whole brain.

"'D. Finally one must use in all other methods dyes, commercial and absolute alcohol and clove oil or turpentine, while we employ a little sublimate and creosote, which are

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[1] MONDINO. Sull'uso del bichloruro di mercurio nello studio degli organi centrali del sistema nervoso. Communic. fatta alla R. Accad. di Med. di Torino nella Seduta del 2 Genn., 1885.

very cheap and inexpensive. In the other methods we must use cover slips, because the high magnification which they require—and then one does not see much—would not be applicable with the thick layers of damar. We do not require this and thereby escape not only expense but also the difficulty of avoiding bubbles of air under large coverslips whereby the preparation is often endangered.'

"It appears to me, apart from all economy of material, time and labor, as well as the convenience of cutting pieces in the microtome so to speak at odd moments without injury to them from the long contact with water, that this method which enables us for the first time to follow in sections the course of nerve fibers through the whole brain shows an advance in the technique of the study of the central nervous system and takes precedence over all others.

"As I pass over the application for the macroscopical study of the brain which Dr. Mondino has also made of this method, I will here in conclusion again assert that the sublimate method takes a high place among the microscopical methods for the study of the nerve centers, alongside of the methods in which silver nitrate plays the chief rôle."

Additional technical notes in Golgi's article, "Das diffuse nervöse Netz der Centralorgane des Nervensystems. Seine physiologische Bedeutung" (from the Rendiconti des R. Instituto Lombardo, Ser. II, Vol. XXIV, Fasc. 8 and 9), pp. 259 and 260 of the German edition of Golgi's works:

"The method which was most useful to me in the investigations described in the first part of this work, was the staining of the nervous elements with mercury sublimate, but with a modification which enhanced its demonstrative value without changing the fundamental procedure. The latter consists (1) in the hardening of the pieces in bichromate of potassium, (2) in the transference from this into a ½% to 1% solution of bichloride of mercury.

"Since I have given in another work (Studi sulla fina anatomia degli organi centrali del sistema nervoso, p. 202) a detailed description of what I call the fundamental part of the method, I consider it fitting to add that the best and finest reactions in the nerve fibers and the interstitial diffuse network was observed by me in pieces (from the spinal cord of the new-born kitten) which had lain a long time (in part over two years) in a one per cent. solution of sublimate after a long preceding sojourn in a bichromate solution (first, Müller's fluid, then, pure bichromate to 3%). Since they were pieces which had lain in the laboratory in this way ready for examination but had not been used, I can, naturally, not tell what influence the long sojourn in the sublimate may have exerted.

"The modification introduced by me, to which I must attribute a certain value for the clear demonstration of fine details and to which I call the attention of the observer, consists simply in a slight addition, viz., the blackening of the glistening white stain which the nerve elements receive by means of the mercury impregnation.

"As is known, the elements treated with sublimate appear black in transmitted light on account of the opacity caused by the reaction but in reflected light they appear white. This difference may be easily observed by turning off the mirror of the microscope.

"This kind of appearance is satisfactory for observation with low or medium magnification, where less fine details are concerned, but it is otherwise with the finer details where stronger magnification is required. In this case the metallic luster of the fine parts, e. g. the finest divisions of the nerve fibers, evidently affects the observation unfavorably by giving the pictures a certain indistinctness. The black stain which replaces the white-metallic brings out better the outlines of the fibers and so increases the demonstrative value of the preparation.

"Inasmuch as the impregnation consists of metallic mercury, the transformation of the metallic white into deep black can be accomplished, according to the teaching of elementary chemistry, by means of a number of reagents. There can serve for this purpose: the sulphite and hyposulphite (particularly sodium sulphite and hyposulphite in 5% solution), the sulphide (of potassium, sodium and ammonium, the first two in 1% to 2%, the third in ½% solutions), sulphuretted hydrogen (one part of the saturated solution and three parts of distilled water). One can also use with advantage the sulphocyanide (of potassium, sodium and ammonium in 2% solutions).

" The solutions of sulphite and hyposulphite, especially the second, render necessary a careful watching of the preparations that they are not entirely destroyed through a disappearance of the metallic impregnation.

" The sulphide (of potassium and sodium) are easier to manage but the complete preservation of the preparations is not entirely certain with them.

"The sulphocyanide acts very well in bringing into view the smallest parts upon which the metallic impregnation has acted but it does not give a uniform black, only a brownish stain. Besides this the cells and fibers under the action of this reagent assume a punctate, almost pulverulent appearance.

"Sulphuretted hydrogen is very disagreeable on account of its offensive smell (a peculiarity which it has in common with ammonium sulphide) and it also has a tendency (as has the ammonium sulphide) to stain those parts containing no sublimate brownish, which impairs very greatly the clearness of the preparation.

" From all these grounds, and, particularly on account of its rapidity and certainty of action, on account of the intensity, uniformity and sharpness of the black stain obtained and on account of the certain permanency of the preparations, the mixture used by photographers to stain and fix their pictures upon aristotype paper is to be preferred to all the other substances given here (naturally for the special purpose of the treatment of the sublimate preparations).

" From the many formulae of this kind which are found in books on photographic technique, I have adopted one which I repeat in a footnote.[1]

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[1] For toning the two following solutions are separately prepared :

(a) Water, 1 liter,
Sodium hyposulphite, 175 g.

"The modification which I have adopted with my sublimate method is as follows:

"The pieces which have been proven to be successfully impregnated are imbedded in celloidin in the usual way and cut with the microtome. The sections are then subjected to the following treatment:

"(1) Washing in distilled water.

"(2) Immersion one or two minutes (they can also remain several minutes without injury) in the above fixing and staining fluid. Several cubic centimeters of the fluid suffice for many sections. The blackening can be observed with the naked eye.

"(3) Careful washing in distilled water.

"(4) If desired, light carmine stain to bring out the cell bodies and nuclei in the fine interstitial nervous network. Acid carmine is best adapted for this according to my experience and I find especially suitable a dilution of this staining fluid with acetic acid and alcohol (equal parts). The fluid into which the sections are brought must have a deep red color.

"(5) Repeated washing in water and then successive transference into alcohol and clove oil and finally mounting in Canada balsam or damar in the usual way.

"Preparations treated in this way possess, besides the above mentioned advantages, the additional one that the fine powdery precipitate does not after a while appear. This precipitate almost always, if there have not been previous repeated and long continued washings, at last spoils the preparations prepared according to the original method."

[TO BE CONTINUED.]

Alum, 20 g.
Ammonium sulphocyanide, 10 g.
Sodium chloride, 40 g.

This mixture stands quiet for 8 days and is then filtered.

(b) Water, 100 g.
Gold chloride, 1 g.

To prepare the bath one mixes
of solution (a), 60 ccm.
" " (b), 7 ccm.
old, combined bath, 40 ccm.

For economy and convenience I use the fluid which has also served for toning, thus for this purpose almost useless.

THE DORSAL SACK, THE AULIX AND THE DIENCEPHALIC FLEXURE.[1]

B. G. Wilder.

Abstract.

In many of the lower vertebrates there is a pouch-like evagination of the diatela (membranous roof of the diacele, or "third ventricle") between the epiphysis and the paraphysis. In *Ceratodus* and in *Polyodon* it is anteverted and very large. In the green turtle it projects dorsad. Its mammalian representative is crowded caudad by the cerebrum and rests upon the retroverted epiphysis. It is commonly ignored in figures and descriptions, but was shown by Reichert. The speaker, without recognizing its homology, figured it in the *New York Medical Journal*, 1885, p. 320. It is large in the sheep and long in the cow and horse. The diaplexuses are continued into it.

Aulix is the mononym proposed by the speaker in 1882 for the "Sulcus Monroi" of Reichert—a sigmoid groove on the mesal surface of the thalamus just ventrad of the medicommissure and connecting the orifice of the mesocele with the porta (foramen of Monro) at either side. His and C. S. Minot regard it as the diencephalic representative of the "*sulcus interzonalis*," the primary furrow between the dorsal and ventral zones of the nervous axis. But recent observations in the neurologic laboratory at Cornell upon embryo kittens render this interpretation somewhat doubtful, and the matter is under investigation.

In 1889, in the "Reference Hand-Book of the Medical Sciences" the speaker called attention to the sharp angle between the prosencephalic and the diencephalic portions of the brain cavities. A recent review of the brains of all vertebrate

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[1] Read before the American Neurological Association, June 4, 1896.

classes warrants the generalization that a marked diencephalic flexure occurs in all Reptiles, Birds and Mammals, while in Amphibians and "fishes" it is absent or insignificant.

THE ECTAL RELATIONS OF THE RIGHT AND LEFT PARIETAL AND PAROCCIPITAL FISSURES.[1]

B. G. WILDER.

Abstract.

The parietal and paroccipital fissures may be either completely separated by an isthmus, or apparently continuous. When so continuous ectally there may still be an ental and concealed vadum or shallow. Disregarding the vadum on the present occasion, the ectal relations of the two fissures may be designated as either *continuity* or *separation.* That continuity occurs more frequently on the left side has been noted by Ecker, Cunningham and the writer. Hitherto, however, statistics have included unmated hemicerebrums as well as mates from the same individuals. The following statement is based upon the cerebrums of 58 adults of both sexes and various nationalities and characters. The speaker has examined 48; the other 10 have been accurately recorded by Bischoff, Dana, Jensen and Mills.

The four possible combinations of right and left continuity and separation occurred as follows:

I. Left continuity and right separation in 27; 46.5%.
II. Right and left continuity in 22; 38 %.
III. Right and left separation in 8; 13.8 %.
IV. Left separation and right continuity in 1; 1.7%.

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[1] Read before the American Neurological Association, June 3, 1896.

When 5 groups of persons are recognized the combinations are as follows:

A. In 8 moral and educated persons, combination I, 62.5; II, 25; III, 12.5.

B. In 23 ignorant or unknown, I, 56.5; II, 34.8; III, 8.7.

C. In 20 insane, I, 40; II, 35; III, 20; IV, 5.

D. In 4 murderers, I, 0; II, 75, III, 25.

E. In 3 negroes, I, 33; II, 67.

So far as these 58 individuals are concerned, the most common combination, *viz.*, left continuity and right separation, is decidedly the rule with the moral and educated, less frequent with the ignorant and unknown, the insane and negroes, and does not occur at all in the murderers. The only instance of the reverse combination (left separation and right continuity) is an insane Swiss woman. The only two known to be left-handed presented the more frequent combination I.

These statistics suggest many special queries and problems, some of which were briefly indicated. But the speaker wished this to be regarded as a preliminary communication and asked the coöperation of other members in the effort to obtain satisfactory records of larger numbers, particularly of brains of well-born, moral and educated persons. For this purpose a blank form was outlined and will be sent upon application.

EDITORIAL.

NEURONYMIC PROGRESS IN AMERICA.

The American Neurological Association, at its recent session in Philadelphia, took a step at once sure and decided toward the simplification and unification of neurologic nomenclature. The Committee on Neuronymy (Drs. H. H. Donaldson, L. C. Gray, C. K. Mills, E. C. Seguin, E. C. Spitzka, and B. G. Wilder, chairman) presented a report which was adopted *unanimously* by the Association, June 6. To give this important measure as wide a circulation as possible we publish the report of the committee as furnished us by its chairman.

The first five sections are substantially identical with reports that were adopted unanimously by the Association of American Anatomists in 1889 and by the American Association for the Advancement of Science in 1890 and 1892. The recommendations are as follows:

1. That the adjectives DORSAL and VENTRAL be employed in place of *posterior* and *anterior* as commonly used in human anatomy, and in place of *upper* and *lower* as sometimes used in comparative anatomy.

2. That the cornua of the spinal cord, and the spinal nerve-roots, be designated as DORSAL and VENTRAL rather than as *posterior* and *anterior.*

3. That the costiferous vertebræ be called THORACIC rather than *dorsal.*

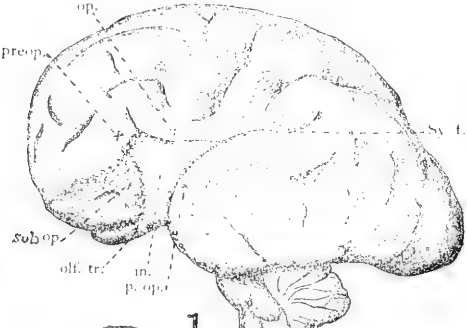
4. That, other things being equal, MONONYMS (single-word terms) be preferred to *polyonyms* (terms consisting of two or more words).

5. That the *hippocampus minor* be called CALCAR; the *hippocampus major,* HIPPOCAMPUS; the *pons Varolii,* PONS; the *insula Reilii,* INSULA; *pia mater* and *dura mater,* respectively PIA and DURA.

6. That the following be employed rather than their various synonyms: HYPOPHYSIS, EPIPHYSIS (for *conarium* and *corpus pineale*), CHIASMA, OBLONGATA, LEMNISCUS, MONTICULUS, TEGMENTUM, PULVINAR, FALX, TENTORIUM, THALAMUS, CALLOSUM, STRIATUM, DENTATUM, MESENCEPHALON, PALLIUM, OLIVA, CLAVA, OPERCULUM, FISSURA CENTRALIS (for *f. Rolando*, etc.), F. CALCARINA, F. COLLATERALIS, F. HIPPOCAMPI, CUNEUS, PRAECUNEUS, CLAUSTRUM, FORNIX, INFUNDIBULUM, VERMIS.

It will be noted that at least twenty (about half) of the names above recommended coincide with those adopted by the European committee in 1895, and that with some others, e. g. CALLOSUM, DURA and CALCAR, the difference is due merely to the elimination of superfluous words.

The next number of the JOURNAL OF COMPARATIVE NEUROLOGY will contain an extended commentary upon the Report by the chairman of the committee.



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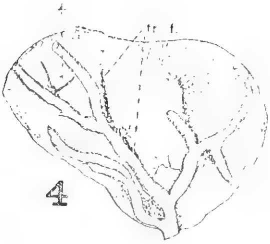

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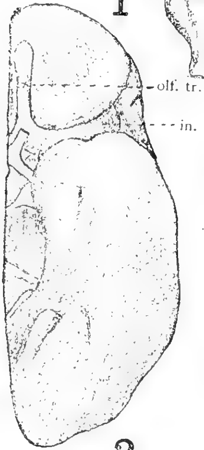

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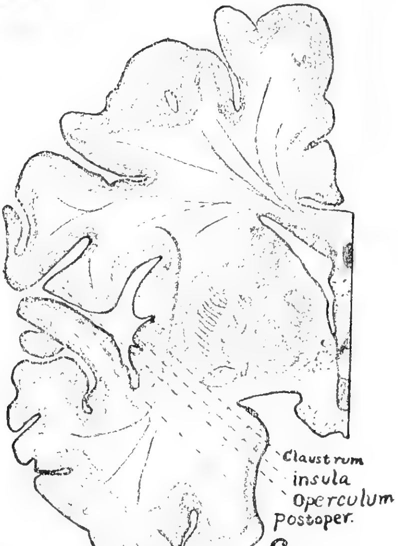

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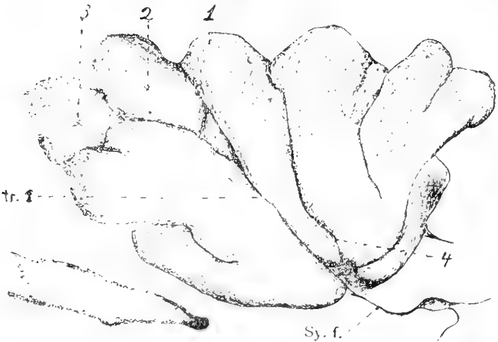

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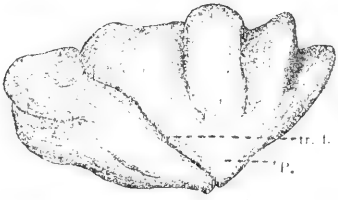

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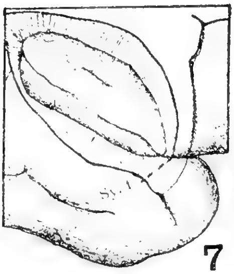

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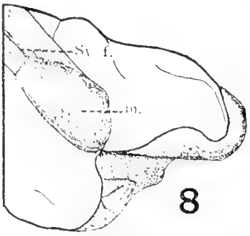

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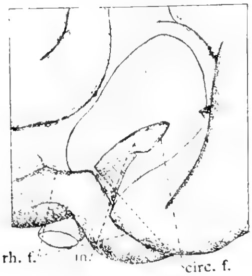

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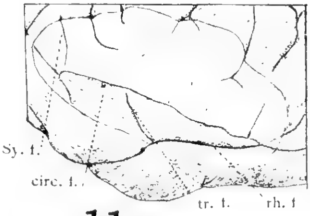

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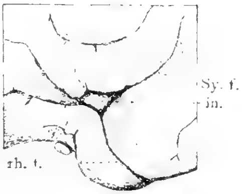

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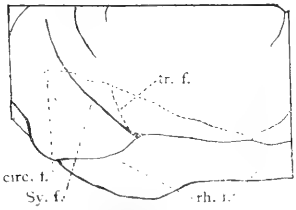

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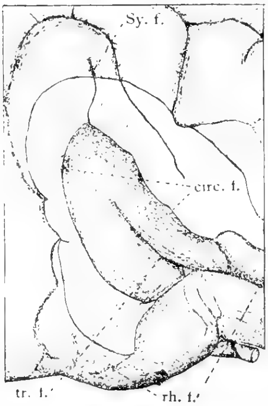

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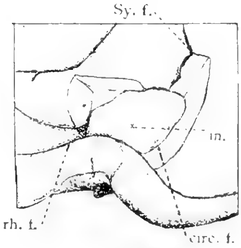

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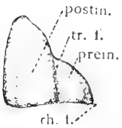

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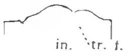

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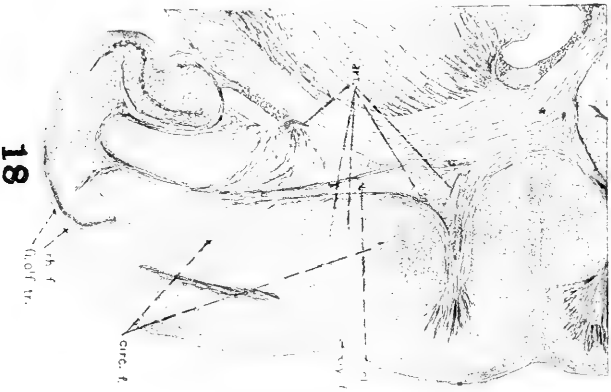

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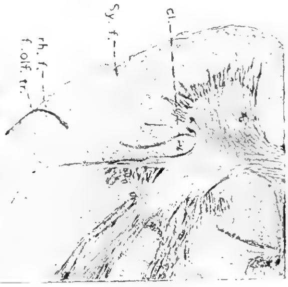

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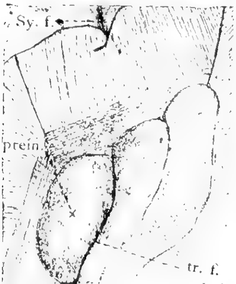

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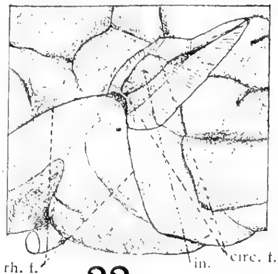

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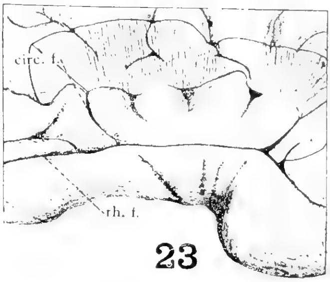

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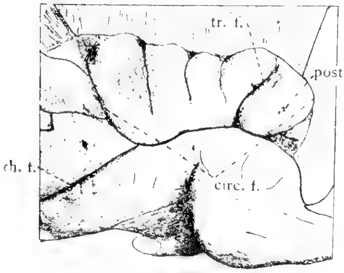

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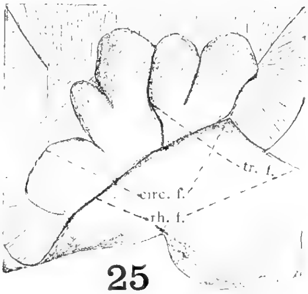

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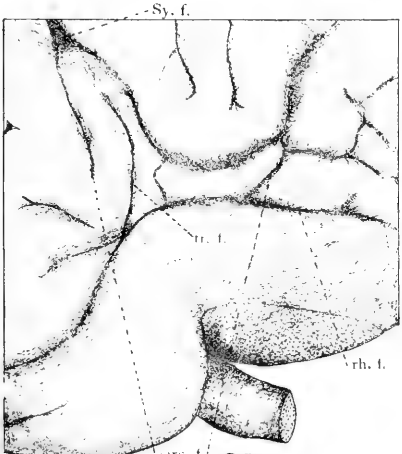

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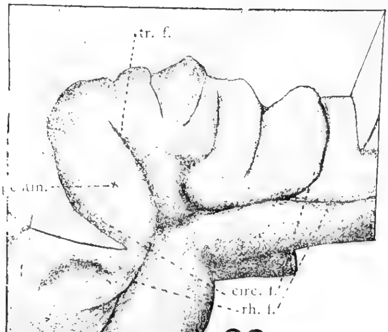

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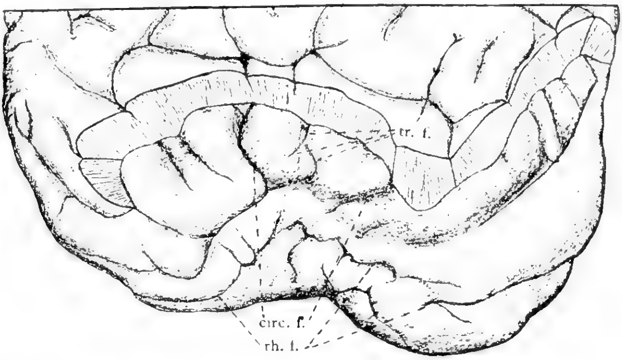

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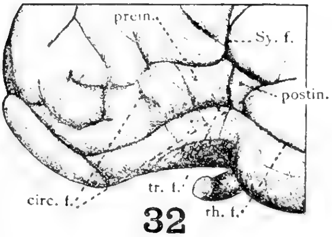

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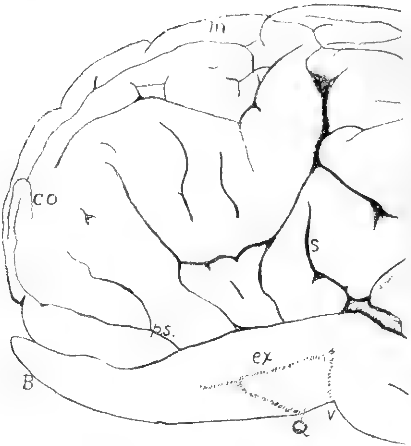

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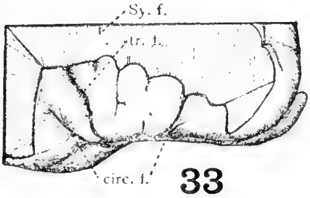

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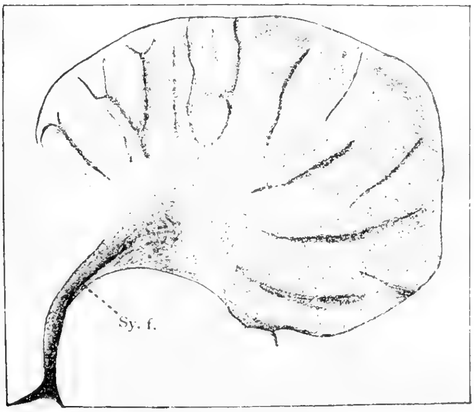

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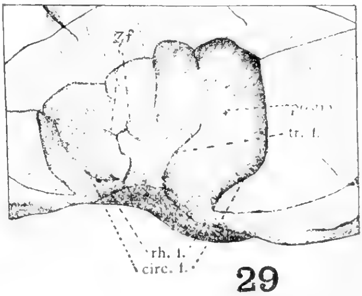

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THE BRAIN OF THE BEE

A PRELIMINARY CONTRIBUTION TO THE MORPHOLOGY OF THE NERVOUS SYSTEM OF THE ARTHROPODA.

By F. C. Kenyon, Ph.D.,
Fellow in Biology, Clark University, Worcester, Mass.

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Introduction.

Since Viallanes' (88) monograph on the brain of the grasshopper (*Oedopoda* and *Caloptenus*) and the smaller but as excellent work of Cuccati on the organization of the brain of *Somomya* appeared nothing has been added to our knowledge of the structure of the hexapod brain. In fact no one seems to have worked at the subject. Such being the case, my endeavor by an application of one of the more recent histo-neurological methods to bring this subject into line with what is now known relative to the stucture of the central nervous system of several other *invertebrates* and more especially of the *vertebrates* will doubtless be appreciated. Here, as elsewhere, an application of the chief of the two recent methods, namely that of Golgi, brings to light facts before known only from inference, and also often materially alters conceptions based wholly upon the older methods of staining. A detailed history of the matter in hand is therefore needed, but since it would add too much to the length of the present paper, the pretentions of which as indicated in the title are very limited, little more than a reference here and there will be given. This course is doubtless excusable since Retzius (90) has already given a summary to which the reader may be referred. Three papers that have appeared since the publication of this author's work may, however, be noted.

The first of these is the paper by Saint-Remy (90) on the brain of tracheate arthropoda. In this the author describes the brains studied histologically of myriopods, chilopods, arachnids and *Peripatus*; but although the work is comprehensive and fills a void in our knowledge of the arthropod nervous system, it is far from treating the subject with sufficient depth, a deficiency mostly due to the method of staining employed. The nerve cells, or cell bodies, following Dietl, he divides into two groups, one composed of large cells well supplied with extra-nuclear protoplasm and with relatively small nuclei having few chromatin elements, the other of small cells having little or no extra-nuclear protoplasm and relatively large nuclei richly supplied with chromatin elements and restricted to certain cerebral areas. To the latter he applies the term chromatin cells in preference to the ganglionary nuclei of Dietl and others.

Two small nerves that he describes for the myriopods may be passed by with the remark that one, namely the nerve of Tömösvary appears to have no homologue in the hexapods unless it be the small nerve mentioned by Newton (79) as arising from the front of the brain of the cockroach and terminating in a small organ near the base of the antenna. The other, or tegumentary, nerve may be the homologue of the tegumentary nerve described by Viallanes (88) for the grasshoppers and consequently, as will be shown in subsequent pages, the homologue of the salivary nerve that I have traced out in the bee.

The most interesting discovery recorded in the paper is that of structures found in the brain of *Scutigra* that he describes as mushroom bodies. The term he bases upon their form and not upon an idea of their being the homologues of the organs of the same name found in the hexapods. But from the fact that their cells are of the chromatic cell type and similarly situated and also from the fact that he seems able to recognize nearly all the parts generally described in the organs in the hexapods it may here be suggested that they may possibly be the homologues of these latter organs. There is needed, however, a more minute and painstaking study than St. Remy has given the structures before one should come to a definite conclusion as to their homologies.

The second of the three papers is that by Viallanes (93) on "The neural centers and sensory organs of articulates" and is mainly of interest here in showing this author's conception of the minute structure of the nervous system. In his earlier papers he did not touch upon the matter, but in his last paper one finds him following St. Remy's grouping of the cells and adding a few ideas upon the finer structure of the fibrillar substance. These ideas were doubtless founded more upon the general results obtained with the methylen blue and the Golgi methods, which by this time had become very generally known, than upon any observations of his own made by the aid of his methods of staining.

He describes and figures diagrammatically three kinds of fibers. One of these, of large size, originates from large cells and passes outside of the central nervous system after first giving off in the latter a few short and fine branches. These he calls motor fibers. Another kind, of much smaller size, enter from cells outside the central system and branching more or less profusely connect with the small branchlets of the first, forming thus the terminations and connections of sensory fibers.

The third kind are short, small fibers originating from the chromatin cells and, branching profusely, connect with the fine branchlets of the other two kinds of fibers. As will be seen in subsequent pages, this general idea is supported by facts, though, as indicated above, it was with Viallanes almost purely hypothetical.

The last of the three papers is one by Binet (94). This author so far as the structure of the dorso-cerebron is concerned seems to follow Viallanes without a question, and deals almost wholly with the ventral system, which he treats anatomically and physiologically. He seems to have added a few new facts to our knowledge of the subject treated, although he leaves very much still to be done. The points at which he seems to have erred or where his treatment is deficient will be noted, when they are closely related to the matter in hand, in subsequent pages. Here it may be noted that he seems to have obtained the beginning of a correct idea of the constitution of the arthropod nervous system based upon the work of Retzius and others employing similar methods; but, failing completely in his use of the Cajal-Golgi method and obtaining but litttle better results with methylen blue, he concludes that, since in any one preparation neither of these methods brings out the whole structure they are not to be depended upon, and then passes on to a dependence upon a modification of the old method of Weigert and becomes lost in the mass of detail that he so much desired to obtain.

The results of other writers will be noted in connection with the descriptions of the structures with which their works deal.

MATERIAL.

The material used has been almost exclusively the common honey bee (*Apis mellifica*), which was at hand in abundance, for which I owe many thanks to Dr. C. F. Hodge. Possibly a thousand or more brains were treated by several of the bichromate of silver methods, and of this number scarcely more than fifteen or twenty per cent. were found successfully impregnated.

METHODS.

Aside from impregnation with bichromate of silver, the methods that I have employed are various, and among these the one that has given the best results, brought details to light most beautifully, has been one using sulphate of copper and hæmatoxylin with brains hardened in from 10 to 20% formol for twenty four hours or longer. Such preparations show the axis-cylinders as purplish-brown fibers within their surrounding slightly bluish sheaths, the nuclei of the latter and of tracheæ, the tracts of nerve fibers and some of the association fibers, clearly marked off from the surrounding ground work of fine branchlets forming the *Punktsubstanz* of the older German writers and the medullary substance of Viallanes. The structure of the cell bodies and their nuclei is also well brought out.

In some cases the freshly excised brains were dropped into 10 to 20% formol, in others they were placed in the following mixture, which gave just about as good results:

10% Potassium bichromate,	40 parts.
5% Sulphate of copper,	40 parts.
Formol, . .	20 parts.

This might be improved by leaving out the bichromate, which is rather unnecessary since the formol likewise has the property of rendering the components of animal tissues insoluble in water and alcohol.

Brains hardened in this mixture were washed for from a little while to some hours in tap water, then for from a few to twenty four hours in 70% alcohol, after which they were dehydrated, imbedded in paraffin, sectioned and stained on the slide in the hæmatoxylin.

In the other cases the sections of the formol-hardened brains were treated with the sulphate of copper (5%). In a solution of this they were left for from a few to twenty four hours or in a warmed solution for from 20 to 30 minutes. They were then washed off in tap water and stained.

The hæmatoxylin mixture that gives the best results is one containing phosphomolybdic acid, though the plain alcohol-water hæmatoxylin used in the method of Weigert and its modifications gave good results for certain details in the roots of the mushroom bodies. The former mixture is that suggested by Mallory and is composed as follows:

10% Phosphomolybdic acid	1 c.c.
Hæmatoxylin crystals	1 grm.
Chloral hydrate .	6 to 10 grm.
Water . . .	100 c.c.

Enough of this was added to a dish of water to give the latter a black appearance, or it was diluted about 1 to 5. From a quarter of an hour to an hour is required for staining. The sections hardened in the potassium bichromate mixture require a longer time than the others.

After staining, the sections were washed off with 70% alcohol and dehydrated or, if too deeply stained, left in the 70% alcohol for some time. With the dilute solution, however, there is not much danger of overstaining, if the process is watched.

For impregnation with bichromate of silver the rapid method of Cajal was at first employed, but only later to be set aside when it was discovered that one in which the osmic acid is replaced by formol gives a much more transparent background for the darkened fibers and cells, thus allowing much thicker sections to be cut, while at the same time retaining the rapidity that has made the osmic acid mixture so excellent. At first the osmic acid was replaced by the same amount (one-fifth) of pure formol, later Strong's suggestion of equal parts of 10% potassium bichromate and formol was followed. This was then modified to 5% bichromate and a smaller amount of formol as follows:

5% bichromate,	80 cc.
Formol,	20 cc.

This gave impregnations as good as the stronger and a little better than the weaker combination while at the same time lessening the formation of a black precipitate that is always found in formol-bichromate mixtures after they have stood some hours. This precipitate was avoided as much as possible by changing to fresh fluid every twenty-four hours. Impregnations may be obtained in brains left unchanged in the mixture until ready for the silver solution. The precipitate must however weaken both the formol and the bichromate and hence operate disadvantageously. I think my failures were more numerous with brains left in the unchanged fluid, (though no experiments were undertaken to settle the matter definitely,) and hence I am not inclined to agree wholly with Kopsch (**96**) when he asserts that the precipitate makes no material difference.

Like this writer, I also found that twenty-four hours in the formol-bichromate is sufficient for hardening and that tissues may then be transferred to pure bichromate. He employed a 3½% solution, however, while I, since it seemed to act more quickly, used a 5% solution.

From three to four or five days immersion in formol-bichromate are necessary for obtaining impregnations of nerve fibers, and almost three for the cells, while the tracheæ may be incrusted almost to the exclusion of nerve fibers after one or two days.

The more or less inevitable precipitate and crystals were of course met with, but on the whole my preparations were comparatively free from them. In fact, judging from the printed experiences of others, I seem to have been more favored than is usual. Only a few cases occurred out of the hundreds of brains sectioned where the precipitate at all resembled the fine branching of the nerve fibers, and in these there was no ground for a deception of the practiced eye, for the angular contours of the precipitate readily distinguished it from the rounded ones of the fibers.

The precipitate gave the greatest annoyance in the layer of cell-bodies. This is so thin on the more exposed parts of the brain that it was usually completely obscured when the brains were brought into direct contact with the fluids. Attempts were made to obviate this difficulty. Formic acid was tried and discarded, as was also Berkeley's (**95**) suggestion of adding a few drops of phosphomolybdic acid to the silver solution just before using. The latter can, in fact, do nothing more than weaken the solution of silver nitrate, and one may therefore as well take a weaker solution to begin with. When this is done and the tissue, after first quickly washing off the bichromate with water, is carefully rinsed in the weak solution, or one that has been previously used, before it is allowed to stand, one will be much less troubled with the incrustation.

This method did not prove as good, however, as one in which the brain was left *in situ* in the head, enough only of the front, top, or side of which was cut away to allow the fluids to enter. In such cases the part most exposed would be incrusted, while that opposite would be entirely free. Other methods were thought of and tried. That of wrapping a brain in filter paper was considered too rough a treatment; covering a brain with celloidin failed. Had the one suggested by Retzius (**92** *b*), namely, of dipping a brain in warm gelatine, been thought of or known in time, it would doubtless have given excellent results.

The nitrate of silver was employed in strengths ranging from ½% to 2%. The stronger solutions, though giving stronger impregnations, less evidence of beading, or fuller fibers, have the disadvantage of being more inclined than the weaker solutions to form artifacts. A solution of 1% strength was finally adopted for leaving the specimens in over night or until I was ready to section them.

Generally only one or two immersions in the fluids was given the specimens, since it was desirable to have only a few fibers impregnated so that very thick sections could be cut and thus give the entire trajectory or as much as possible of a fiber unobscured by other details.

The impregnated brains were transferred to absolute alcohol and then to celloidin. Where they were entirely free from the head or from chitinous particles that would tend to prevent them from becoming fairly saturated or surrounded with the celloidin, sections wese cut within two hours from the removal from the silver solution. But where they were surrounded by the chitinous cephalic capsule from six to twenty-four hours were found necessary to form a celloidin block of a consistency sufficient to prevent tearing and breaking of the sections.

Sections were cut all the way from twenty to two hundred and ten microns thick, thus, in the thickest, making only three or four frontal sections to a brain.

General Description.

External appearance.

Under the general term "brain" I here understand the whole of the neural mass included within the head, excepting only the two small ganglia generally known as the stomatogastric ganglia. The optic lobes and the subœsophageal ganglion are part of it. There is no real ground for leaving the latter portion out as is generally done under the term subœsophageal. Even when it is widely separated from the larger mass and is to be found crowded back into the pro-thorax, there is abundant reason, as shown by the physiological experiments of Binet (94) and others, for retaining this portion under the general term brain. Hence in subsequent pages it will be referred to as the ventro-cerebron in contrast to the super-intestinal portion or dorso-cerebron.

The optic lobes will be omitted from this paper for consideration in a later one.

The bee's brain thus limited is, roughly speaking, when viewed from the front, a quadrilateral structure, with rounded angles. Setting aside the ventro-cerebron, which projects backward, it is considerably compressed antero-posteriorly (Pl. XX), and abuts closely against the middle upper portion of the posterior walls of the head, leaving a very considerable space in front filled with tracheal air-sacs and the whitish, often yellowish or orange racemose bunches of the salivary glands. These latter organs also fill in the smaller spaces behind the brain and are closely applied to it. On the dorsal side are three small protuberances (Pl. XVII, XX) with black tops, or the so-called ganglia of the ocelli. Below in the lower third the brain is pierced by a large oval opening, the œsophageal foramen, with its largest axis vertical. Near the roof of this is the longitudinal median nerve of the stomatogastric system. On either side and below the foramen are the rather conspicuous antennal lobes forming the greater portion of what has been described as the deuto-cerebron. The ventro-cerebron, as already mentioned, projects considerably backwards, but it is so closely united with the dorso-cerebron by extremely thick and short œsophageal commissures that it is very readily recognized as part of the brain. So compact is this deuto-trito-cerebral portion of the brain that were it not for the fact that the labral nerves are recognized as arising from it, indications of the trito-cerebral lobe would be recognizable only in sections. Even in these its boundaries are indefinable.

THE CEREBRAL NERVES.

From the lower side of the antennal lobe there is given off the large antennal nerve, which passes forward and slightly downward to the entrance of the antennæ. From the lower surface behind the origin of the large nerve there originates a small one that may be readily traced in sections to the antennal muscles within the head. This, which I will denominate the *antenno-motor internus,* in contradistinction to the other, or *antenno-motor externus,* was first discovered and traced to its termination in the muscles by Newton (79) in his study of the brain of the cockroach. It is described by Viallanes (87) in his paper on the brain of the wasp as the "nerf antennaire accessoire" and was correctly identified by him with the nerve described by Newton, although he was unable to trace it to its termination in the muscles. Doubtless it may be found as a separate nerve in all tracheate arthropods. One occupying the same position I have recognized in *Scalopendrella immaculata* and traced into muscles that I supposed to belong to the antennæ.

Behind this internal antenno-motor nerve and immediately behind the base of the antennal lobe there is a somewhat larger nerve that I have traced towards the mouth-parts of the bee and from its position take to be the labral nerve. This arises from the trito-cerebron and may be seen in fragment in the photograph (fig. 2, Pl. XIV), which is of a section slightly too far forward to show the lobe and the entering nerve root.

From the lower side of the ventro-cerebron (Pl. XX) there arise not far apart from each other three pairs of large nerves that like the one just described may be readily traced to the mouth parts. Since in most of my preparations these parts were cut away to allow a free access of the fixing fluids to the brain or to free the object as much as possible from chitinous parts to avoid tearing during the process of sectioning, I have not yet traced the nerves to their endings. From their position, however, I infer them to be the mandibular, maxillary, and labial nerves. From the posterior lower surface of the ventro-cerebron there arises a small seventh pair of nerves directed backwards and downward toward the region just below the foramen magnum. Just how they terminate or what their function may be I have not thus far been able to determine. They were seen by Viallanes (87) in the wasp, but were left as now still to be traced.

In his monograph on the brain of the Orthoptera, Viallanes (88) described under the name of "nerfes tegumentaires" a pair of nerves emerging from the surface of the brain and passing on to the roof of the head. These appear to be nothing more nor less than a pair of nerves that he found in the wasp the year before and described as nerves of unknown terminations.

This eighth pair of nerves is readily seen and traced in the bee and one may be recognized in section in the lower photograph in plate XVI. Both in bichromate of silver and in hæmatoxylin preparations I have been able to trace out its entire course and to show that Viallanes' denomination of tegumentary nerve is entirely a misnomer. It arises from the side of the ventro-cerebron where its root enters the latter, passes in, somewhat downwards and backwards, towards the median line of the latter, makes a turn backwards and becomes lost in the general mass of fibrillar substance. The nerve (Pl. XVII) closely adhering to the posterior surface of the brain and beneath the general envelope of the latter passes outwards and upwards until it reaches the upper portion of the posterior surface of the inner or third optic fibrillar mass or ganglion, where it branches. One branch continues almost perpendicularly upwards, passes out of the brain envelope and branches among the lobes of the salivary glands. In bichromate of silver preparations the branches may be followed into the lobes, but I have not yet seen the finer terminations. The other large branch continues outward along the supero-posterior surface of the optic lobe, branching and leaving the envelope from time to time, and may be followed to the basement membrane of the retina where it finally emerges to pass into the glandular lobes situated in proximity to that structure. The nerve, then, instead of having anything to do with the integument, is the nerve to the salivary glands, and is doubtless made up entirely of efferent fibres.

The small pair of nerves described by Newton (**79**) as arising from the anterior surface of the brain in *Blatta* and going to the small white spot near the base of each antenna, are not, so far as I have been able to discover, represented in the bee.

THE GENERAL INTERNAL STRUCTURE.

Internally the brain is composed of a mass of very fine fibrils scarcely recognizable as such in ordinary preparations, which is very well called fibrillar substance. The upper portions of the anterior surface of this below the mushroom bodies to be described later and the corresponding part of the posterior portion of each of the two lateral lobes are directly covered by the membrane forming the perineurium. But in the region of the mushroom bodies, laterally, in the posterior median furrow, and below, about the greater part of the antennal lobes, filling the space between these and the proto- cerebron, and the lower and lateral surface of the ventro-cerebron (the upper surface of the latter is bare) it is covered by heaps of cells which spread out into layers of only one or two cells deep. Processes from many of these cells are gathered into large bundles which, penetrating the fibrillar substance, give it—both the brain and the ventral system as seen in sections—a lobular appearance that has been the subject of no inconsiderable amount of painstaking and lengthy and as tedious description, notably by Viallanes, and later by Binet (**94**) in his paper on the sub-intestinal nervous system of insects. The fibers thus entering become lost in the fibrillar substance by repeated branching or continue first to more distant parts, thus forming connecting tracts. This relation of the fibrillar substance and the fibers may be readily seen in the accompanying photographs, and in most preparations by ordinary staining methods. The assistance of the method of impregnation with bichromate of silver or that of intra-vitam staining with methylen blue is necessary to determine the relations of cells, fibers and fibrillar substance completely.

THE TYPES OF NERVE CELLS.

By the assistance of the bichromate of silver method we may imagine a cell with a nerve fiber dividing at some distance from the cell body into two branches that form with it a T or a Y as probably the most typical of the nerve cells of the bee, or probably of arthropods in general. The assertion does not hold good completely, for there are cells in the optic lobes and even in the central part of the brain in which all the branches given off appear as very small branches of large fibers.

To classify for convenience of description the various modifications met with in the brain one may divide them into:

1. *Afferent* or *sensory fibers* in which the cell body is situated somewhere in the neighborhood of the external (to the brain) organ of sense and sends its neurite into the brain and its dendrite into the sense organ. Such cells may be called bipolar, and in them, as in all other nerve cells, the only criterion of the difference between dendrite and neurite is in the direction of the passage of the neural impulse with reference to the cell body, or to the trunk of the fiber leading to the cell body. Such fibers do not penetrate far into the brain, where they may terminate in a mass of fine branchlets as in the case of the fibers from the antennæ. In other fibers the terminal branching is more or less loose or not massed together, as in the case of whatever sensory fibers there are entering through the labral, mandibular, maxillary and labial nerves or from the ventral cord.

In the accompanying diagrams this class of fibers and all others bearing sensory stimuli into the portion of the brain here considered, as from the optic lobes and the ventral cord, are colored blue.

2. *Connecting fibers* in which the cell body is situated to one side of the track of the passing stimulus—assuming that it does not necessarily go to the cell body—and in which the dichotomous T- or Y-shaped branching is most easily recognizable. The peripheral of the two branches connects with the

terminations of the sensory fibers of the first class and, since it bears the transferred impulse inward, may be called the dendrite. Usually it is shorter than the other branch that, with others of its kind, passes as a tract of fibers through the fibrillar substance to the mushroom bodies, in which it breaks up into a bushy or arborescent mass of branches, or to other parts of the brain, where the branching is of a more open kind.

The fibers connecting the sensory fibers of the antennal lobes with the mushroom bodies are most typical of this class. Others that must be classed along with them enter from the optic lobes and along with them are represented in violet in the diagrams. Others found connecting the central body, later to be described, are doubtless to be classed here, since this body seems to be in connection with the fibers of the ocelli; but owing to the unsatisfactory condition of my present understanding of this body have been left in black. The mode of branching at the ends of the dendrite is represented in fig. 15, Pl. XXI, while the branching terminals in the mushroom bodies are shown in figs. 17, 18, 21, of the same plate. Most of these fibers appear to be provided with a nucleated sheath.

The representation of fibers found in the central body in figs. 32, 37, Pl. XXII, by comparison with figs. 17 and 21 of the preceding plate, which beyond a doubt represent the receptive terminations, would seem to indicate that the former are dendritic. Fig. 18, Pl. XXI, shows the terminations of the neurite-branches in the mushroom bodies as seen under a magnification of 586 diameters.

3. *The cells of the mushroom bodies.* These fall under the head of Y-shaped cells and consequently follow the class just described, but will be left for consideration along with the bodies which they largely compose. They are represented in red.

4. *Efferent fibers* which originate from cell bodies situated within the brain and bear efferent stimuli to muscles, glands or to cells outside of the brain are represented in the diagrams in brown. The cells of this order seem to depart widely from the simple T-shaped general type as is shown in fig. 36, Pl.

XXII, which represents the best specimen of motor cell that my preparations offered. That it is motor in nature is assumed from its general appearance, resembling to a certain extent the motor fibers described and figured by Bethe (95), and the fact that it is cut off near the cut end of a large fiber not figured that passes into the antenno-motor nerve and with which it appears to have been continuous, but on account of a slight bend outside the plane of the razor was cut in two. This appeared in a nearly sagittal section. In a thick section cut in the frontal plane, or nearly transversely to the main axis of the animal's body, fibers were seen, such as one represented in Plates XVII and XX, sending a process into a tract of fibers that appeared to pass down behind the antennal lobe, apparently into the root of the antennal nerve, which were therefore thought to be motor fibers. Combining these two with what was seen of fibers in other sections in about the same locality as the motor cell mentioned it would appear that the large motor cells send a process into the fibrillar substance, which almost immediately gives off small branches that may end at a considerable distance from their point of origin. The process becomes very much enlarged for a considerable extent of its course and may even send off branches of considerable size before passing on into the root of a nerve as a small fiber.

5. *The commissural fibers*, which are doubtless of the general T-shaped form, though I have not been able to find their cells of origin. They pass from one side of the brain to the other and may be represented by the fibers composing the superior commissure. The fibers composing the so-called commissure of the optic lobes may possibly also be classed here. Other fibers there are in plenty than those gathered into tracts passing between the two halves of the brain, but they are better classed with the next group.

6. *Association fibers* seemingly serving the purpose of connecting the elements already described with one another. These are mostly large profusely and irregularly branching forms some of which are shown in plate XXII. In some cases I have been able to make out the cells of these, in others I have not.

They all form a promiscuous group that might be, but for lack of a better knowledge of them and their cells of origin, may as well not be, subdivided. Almost all of them are known only from fragments of which those shown in plates XXI and XXII are the best examples. Some of them may possibly even be fragments of motor-fibers.

To these groups may be appended two others, one represented by the enormous fibers from the ocelli and the other by the equally enormous fibers situated near the dorsal surface of the ventral system and of the ventro-cerebron. They will be considered in connection with the ocellar nerves.

THE CONNECTIONS BETWEEN NERVE FIBERS.

What facts I am able to bring forth bearing upon the "contact" idea and the old "mesh-work" idea of the fibrillar terminations, though more properly considered here, I will defer until I have described the mushroom bodies, in connection with which the facts mentioned occur.

TRACHEÆ.

Besides these neural elements and the sheaths surrounding some of them, there are to be found large numbers of tracheal fibers. In bichromate of silver preparations they are the first elements to become impregnated and then are brought plainly into view. The larger branches may be very readily recognized in hæmatoxylin preparations. Their general tapering form and the time of their taking up the bichromate of silver prevents their becoming confounded with nerve fibers.

To explain their origin it must first be noted that the brain of the bee is surrounded by a number of tracheal sacs, the inner walls of which closely cover it. Here and there tracheal outgrowths from the sacs especially in the neighborhood of the cell clusters pass into the brain. They branch more or less profusely among the cells and then send smaller branches into the fibrillar substance as shown in fig. 29, Pl. XXII, which represents a camera drawing of the tracheæ of one of the mushroom bodies. Tracheæ almost identical in appearance with these, are found on all sides of the brain. Others, however, of a larger size are also found that enter into the fibrillar substance more deeply, and gain their entrance along with some nerve fiber or bunch of fibers.

In no case have I been able to make out a tracheal network such as described by Emil Holmgren (95) for the spinning glands of lepidopterous larvæ. So far as bichromate of silver preparations thus far made show, the branchlets all terminate independently of one another. In some of my copper-hæmatoxylin preparations there are, however, certain details that recall Holmgren's figures which lead me to suppose that a tracheal network may exist.

Special Description—the Proto-cerebron.

THE MUSHROOM BODIES.

From this hasty general account of the brain and its constituent elements I pass to a more detailed consideration of its parts and choose for the first the mushroom bodies as being the most conspicuous and as the better serving for the orientation of other parts later to be described.

These organs were first noted by Dujardin (50) in a study of transparent preparations *in toto*. From their slightly lobular or folded appearance he compared them with the convolutions of the human brain and described them as "lobes à convolutions" probably associated with the intelligence of the insect. As will be seen in the sequel, this supposition has very much more in its support than the crude or undeveloped morphological technique of that time was capable of bringing to light. Later they were again found by Leydig (64) who mentions them under the term "Gestieltes Körper." They were again described by Rabl-Rückhard (75) who, according to Viallanes (87), first correctly described the calyx. But it was not until Dietl (76) had applied microtomy and stained his sections with osmic acid that a complete description of their whole structure was obtained. Since that time they have been so often re-described for insects representing the different orders of hexapods that they may be considered as fairly well known structures very characteristic of—especially the higher—hexapods. Special swellings found on the brains of certain of the crustacea have been compared with them, but it is to be seriously doubted, I think, whether such swellings or cellular heaps are properly to be homologized directly with them. In neither Retzius' (90) figure of the brain of *Astacus fluviatilis* nor in Bethe's figures of the brain of *Carcinus mœnus* can I find cells having the relations and the appearance of those that I find in the bee. I have noticed nothing resembling the structures in isopods, or amphipods, nor I have found indications of them in the brains of *Pauropus*, *Polyxenus*, juloid diplopods, *Scolopendrella*, *Lithobius*, nor even in several forms of *Thysanura* that I have examined. If cells homologous with those filling the cup-like calyx of the mushroom bodies of the bee are at all present in these forms, they are so undifferentiated as to be indistinguishable from the general mass of cells about them.

The Calyx-Cup.

The four bodies that in the bee and the Hymenoptera in general constitute what may be called the calyx-cup form the upper portion of the proto-cerebron, and are arranged side by side, a pair to each lateral lobe. In section, as shown in the photographs of Plates XIV and XV and in optical section in transparent unsectioned preparations, they are very noticeable from the curved masses of fibrillar substance that form the base and walls or calyx of each making them resemble optical sections of so many cups. Each cup holds a mass of cells that fill it to the brim. The walls of each lateral pair are nearly or quite contiguous, except distally where they diverge from one another leaving a space filled with a mass of small cells, as is also the space between each outer cup and the inner fibrillar mass of each optic lobe. Viewed from above they would appear elongated antero-posteriorly or with their included cells as four folds along the top of the brain, each extending backwards and inwards toward the median line. The inner one of each pair is broadest anteriorly and somewhat overlaps its outer mate or appears to crowd it back. On the other hand the outer one is broadest and extends the farthest posteriorly. Other general details may be made out from the photographs. Below them antero-laterally, below their whole posterior extent, or occupying the spaces between them and the rest of the proto-cerebron are to be found ganglionic cells of various sizes, but mostly of the small kind to be described elsewhere. There is also a small mass of cells continuous with the mass between the upper portion of each pair of cups, but which in the sections photographed appear to be cut off from the larger mass. Each fibrillar mass is outwardly clothed by a thin nucleated membrane.

These are the bodies described by Dujardin as "lobes à convolutions." By later writers they are variously called. Leydig (64) described them as "Lappen mit Windungen;" Rabl-Rückhard (75) as "Rind Körper;" Dietl (76), Berger (78) and Cuccati (88) as "Pilzhutförmiger Körper;" while Newton (79) introduced the name calyx, which was adopted by Packard (80) and Viallanes (87 and 88).

The bodies reach their highest development in the Hymenoptera and are much larger in the social wasps than in the honey bee. In *Blatta* the lateral walls of the cups are much reduced, and in the Coleoptera the cup-like form is scarcely recognizable, while in *Forficula* and *Acridum* the fibrillar substance only forms a broad plate. Even this is scarcely, if at all, recognizable in *Dytiscus*. In *Tabanus* and *Somomya* the four folds are reduced to two and in the former of these genera are scarcely to be distinguished by a comparison of their cells with those surrounding them. In the Hemiptera they are not distinguishable at all.

The Stalks of the Mushroom Bodies.

From near the middle of the lower surface of each cup a column of fibrillar substance passes into the main mass of the proto-cerebron. In the bee these are much shorter than in other forms. The inner one descends almost perpendicularly downward for a short distance where it is joined by the one from the outer cup, which is somewhat longer and has an inward and somewhat forward course. In transverse sections the columns or stalks present a nearly circular outline and are distinctly delimited from the surrounding mass of fibrillar substance.

The Roots of the Mushroom Bodies.

At the place of union of the two stalks there are given off two masses of fibrillar substance of cylindrical shape, but with a diameter considerably greater than that of the stalks. One extends obliquely downwards towards the median plane of the brain where it nearly abuts against the one from the opposite side (fig. 2, Pl. XIV). Sometimes, as shown in the figure, the point of one may slightly overlap the other. Like the stalks, this structure is easily distinguishable from the surrounding mass of fibrillar substance even in ordinary preparations.

The other, which may be distinguished from the one just described, or inner root, by terming it the anterior root, extends straight forwards and abuts against the peri-cerebral membrane. It is longer than the inner root, but has nearly the same diameter. In section it is nearly circular (fig. 1, Pl. XIV), and in the transparent preparations *in toto* appears as a circular body in each proto-cerebral lobe, considerably above the antennal lobe. For most of its course it is well delimited from the surrounding mass, but anteriorly it becomes fused with the surrounding fibrillar substance on its lower inner side. In this region it may be seen to be entered by many irregularly branching fibers, even in preparations stained with hæmatoxylin (fig. 1, Pl. XIV).

THE MINUTE STRUCTURE OF THE MUSHROOM BODIES.

In sections cut in the frontal plane and treated with sulphate of copper and hæmatoxylin the cells filling the cups of the mushroom bodies appear to be of two kinds, both arranged one above the other so as to present the appearance of tiers arranged more or less radially with respect to the calyx as a circumference. Laterally they are much larger than those in the middle, which in such sections form a dark colored triangle (fig. 1). Those at the side are much lighter. In sections of brains fixed and colored in von Rath's platino-osmo-picric acid mixture the contrast between the two kinds is noticeable only upon close inspection and then only as a difference in size. After staining with fuchsin brings out no further difference. The chromatin elements then appear more distinct and more numerous, but both seem equally well supplied. Nor is there a difference in the presence or absence of a small dark colored nucleolus in preparations treated after the copper-hæmatoxylin method. The slight chemical difference indicated by the difference in depth of coloring shown by the latter method is, however, supported by a difference in the fibers given off from the cells, as will be seen a few lines further on.

In similar sections of the brain of a wasp I find but one size in the cells of this region. But two sizes occur in the cockroach according to Flögel (**78**) and are doubtless to be found in other forms. But one or two kinds, the cells of the mushroom bodies in the hexapods generally, and of the regions compared with them in crustacea, are strongly distinguished from nerve cells elsewhere in the brain, and in the whole nervous system for that matter, in being nearly devoid of extra-nuclear protoplasm. This fact led Dietl to term them ganglionary nuclei, a term that was later altered by St. Remy (**90**) to the equally characteristic one of chromatic cells.

Between the tiers of cells fine fibrils and tracheæ make their way to the inner surface of the cup, the tracheæ also branching among the cells as already described or figured in Plate XXII (fig. 29). The nerve fibers may be traced, with considerable difficulty, however, to the cells. In bichromate of silver preparations both cells and fibers easily impregnate and where the section is in the right place or where too many elements have not become darkened, the fibers are readily traced into the fibrillar substance forming the calyx-cup (fig. 18, Pl. XXI).

Here the fibers from the larger or marginal cells break up into a series of fine branches that again subdivide and produce a bushy or arborescent formation that reaches to the outer wall of the calyx and of which the drawing (fig. 18, Pl. XXI), although made with a camera, can give but a poor conception. The preparation from which this drawing was made is one of the first that were fairly well impregnated, but not so well as later ones, and is far from showing the richness of branching seen in the latter. Further, the branches are delicate and the smaller ones covered with fine short processes that give the whole a more or less feathery appearance. The preparation is not black, but of a delicate reddish brown tint. The difficulty of representing them and the fact that the connections with the cell bodies are poorly represented in the other preparations caused me to be satisfied with the figure given.

The processes of the smaller cells forming the pyramidal central heap, as shown in the same figure (fig. 18, Pl. XXI), also pass into and branch in the fibrillar calyx-cup. These branches resemble those of the other fibers, but, as shown, are far less numerous. Moreover the processes from the cells may be slightly smaller.

As shown in the figure, the processes do not always follow the most direct line to the fibrillar substance, but seem often to bend about the intervening cell-bodies. Consequently little dependence can be placed upon even the best of preparations by ordinary methods for tracing fibers for any considerable distance from the cell body towards the fibrillar substance. Fibers may readily be seen, however, passing from the cellular mass into the calyx, for between the two there is a narrow space but loosely filled with fibers, which may be seen more or less indistinctly in the photographs.

In this space are to be seen small round deeply stained bodies, which upon close examination and by comparison with sections cut in a plane parallel to the inner walls or to the base of the calyx are seen to be composed of a large number of very fine fibers arranged parallel to one another and forming thus a closely crowded fiber tract. These radiate in all directions from the place of union of the calyx and the stalk from which they seem to come. Outwardly the fibers separate and gradually spread out over the whole inner surface of the cup. Such phenomena are best shown in bichromate of silver preparations, but may be seen in preparations by ordinary methods and have been figured by earlier writers (Viallanes, Cuccati).

A further study of bichromate of silver preparations will show that each fiber from one of these bundles after its separation from the rest becomes continuous with a fibrillar process entering the calyx-cup from one of the cells above. Thus there is formed a nerve cell of the general Y-type (fig. 18, Pl. XXI). No other nerve cells are found in the cups.

Before continuing the consideration of the fiber just noted it may be well to mention the form of the cell bodies here and of those elsewhere. The larger number of successful impregnations of the cell bodies of the cups present a perfectly smooth outline. Very many, however, have from one to five or six projecting processes, which may branch. In this respect the smaller cells of the pyramidal group are exactly like the larger border cells, though such a condition did not happen to be shown in the section from which figure 18 was drawn. To determine whether they differed in this respect the sections of several brains were examined, resulting in the conclusion just given. Many of the cells resembled those shown in figure 19, Pl. XXI. Whether these processes are protoplasmic continuations of the cells to which they are attached or whether they represent merely filled up adjacent inter-cellular spaces, is a rather difficult question to answer. Here is one of the most serious difficulties presented by the bichromate of silver method. A few such cells I have seen in the optic lobes, but there as elsewhere cells with smooth contours seem to be the rule, and the rule might be taken to indicate an artifact nature for the processes in question. Further than this I find no reason for believing them to be artifacts. On the other hand, the fact that there was no evidence of undoubted artifacts in the immediate neighborhood of the cells described, together with the peculiar circumstance of the extremely small amount of extra-nuclear protoplasm in the cells filling the cups and their generally crowded appearance, would indicate that probably the processes are really parts of the cells with which they are connected.

Returning to the fibers of these cells, it may be noted that it is the bichromate of silver method alone that is able to show their course and termination. Fortunately there is no difficulty, such as there is with the fibers of other regions, in determining their immediate relationships completely. The bundles of fibers already mentioned as radiating from the place of union of the calyx and stalk as though coming from the latter do so, or rather, to start from the parent cell, pass down into the stalk. At the junction of the stalk and the two roots each fiber divides into two branches one of which passes obliquely downward towards the median line, the other straight forward to the anterior surface of the brain. Both terminate without further branching, and the inner group form the inner root, and that directed forward the anterior root of the mushroom bodies. Throughout their whole course from the entrance into the stalk to their termination in the inner and the anterior roots the fibers remain parallel, the only deviation from a straight line being a slight waving. They neither decrease nor increase in size but in the stalk they sometimes, though not always, appear to be covered by fine short processes that can neither be described as thread-like nor tooth-like. These may be artifacts, but I am inclined to think that their non-appearance might as well be accounted for by defective impregnation.

There is found, then, in the mushroom bodies a nerve cell with a smooth or irregular body sending a process into the fibrillar substance forming the calyx, branching there profusely and sending a second process from the first down through the stalk and forming an inner and an outer branch. As will be seen beyond all doubt a little farther on, the branching process in the calyx is the dendrite and the second process is the neurite. In the relation of its neurite to other fibers it recalls to some extent the relation between the neurites of the cells of the granular layer and the dendrites of the cells of Purkinje in the mammalian cerebellum, but as a whole the cell seems to be unique among all known nerve cells.

Fibers Ending in the Calyx.

In bichromate of silver preparations, besides the branching dendrites of the cells just described, there may also be seen a large number of other fibers all somewhat coarser than the fibers of these cells and permeating and branching in the calyx in all directions (figs. 23, 26, 27, Pl. XXI). Often they are impregnated almost to the exclusion of the fibers from the cells above. At other times both appear, but then they most often obscure one another, making it necessary to section a large number of brains in order to find cases sufficiently free from a repetition of details to enable one to determine the form and relationships of the various fibers correctly. When such cases occur it is found that the fibers terminating in the calyx all make their entrance in the neighborhood of the junction of the calyx and stalk, or from the under surface of the cups. All appear to send a main fiber in a circle about the head of the stalk and from this to radiate numerous branches to the more distant parts.

The difference in size and mode of branching of these entering fibers allows two kinds to be distinguished. In the smaller kind of branches radiated from the region of the stalk, one slender kind branch more or less irregularly and repeatedly, terminating finally in an irregular swelling such as shown in fig. 27, which represents a magnification of about 583 diameters.

The larger kind (fig. 23) radiate off from the portion encircling the head of the stalk a number of stocky branches that after penetrating the surrounding mass of fibers for a relatively short distance branch out into a cymose head. Other portions aparently of this same fiber pass out into more distant parts of the calyx. The figure given was drawn with as much care as possible and well represents what was seen, but appearances are often deceptive, and I am inclined to think there are two kinds of fibers here instead of one as represented. It may happen that fibers overlie one another in such a way as to appear as one continuous fiber, a deception that, especially in thick sections, the most careful focusing will not always avoid. The fibers shown in the figure as immediately surrounding the junction of the stalk and calyx appear to be restricted to the region covered by the median group of small cells. The others appear to have gained an entrance to one side of the stalk and take in a larger region, besides appearing to have a different mode of branching.

The difference in size between figs. 23 and 26 is mostly a difference of magnification, which in the former is 121 and in the latter a 102 diameters, yet the fibers represented in fig. 23 are actually the coarser.

Just where either of these two kinds, the fine and the coarse fibers originate, or what other parts of the brain are connected with the mushroom bodies by them is yet to be determined. Almost all that can be said is that six different tracts of fibers terminate here, two from the optic lobe, one from the ventral region, and three from the antennal lobes. To these may probably be added a seventh of a commissural nature. These tracts will be described further on.

The Fibers Ending in the Stalk and the Roots.

In certain places (fig. 1, Pl. XIV), as already pointed out, fibers entering the anterior roots of the mushroom bodies may be very readily seen in sections treated after the copper-hæmatoxylin method. In preparations by the bichromate of silver method others may be distinguished. One large tract traced to its cells of origin behind and between the stalks of the mushroom bodies by Viallanes (87) in his study of the wasp spreads out on the side of the anterior half of the anterior root and branching sends one branch into it. The fibers of this pass nearly horizontally across or obliquely downwards to the opposite side giving off from their upper side several subbranches (fig. 21, Pl. XXI) that after passing a greater or less distance upward break up into a thickly bushy head. These all occupy almost the same level so that often in specimens treated with osmic acid or with hæmatoxylin, especially the latter, the appearance is presented of several bands crossing transverse sections of the roots. Figures 3 and 4 show these bands excellently, and represent the two roots as seen in a slightly oblique section treated with copper sulphate and a solution of hæmatoxylin made according to one of Weigert's formulæ. Bands of this sort occur throughout the whole extent of the root. In the inner root also similar bands, though less conspicuous, are found, but there instead of being transverse, they are longitudinal.

The fibers just described are more or less coarse, considerably more so than fibers entering the lower outer side of the root behind them (fig. 28). The sub-branches of the second kind of entering fiber also take an upward course and break up into a series of branchlets, which do not, however, form a compact bushy head. Where their cells of origin are situated I am unable to say further than that subsequent studies will probably show them to be situated somewhere beneath the calyx-cups, either to one side of or behind the stalks. Their outward-going branches seem to penetrate into the lower lateral depths of the brain. A third fiber enters this same region at a lower level and appears to come from the lower lateral side (fig. 28).

Behind these fibers near the junction of the roots, or in the plane shown in fig. 1, Pl. XIV, on the left, fibers are found entering on the lower inner side which present a more delicate appearance and are otherwise different from those first described (fig. 28). They branch more or less dichotomously and end in a tuft of branchlets which in preparations with osmic acid or hæmatoxylin give rise to the broken appearance shown in the section of the left root in fig. 1, a comparison with which will show that fig. 28 is not properly oriented and that it should be viewed from the corner of the plate so as to make the branches crossing the dotted ring take a nearly horizontal course.

In the region of the junction of the two roots and the two stalks rather coarse fibers are found (fig. 17) considerably resembling those first described, whose more or less bushy terminals along with those last described produced the knotted appearance described by Rabl-Rückhard (75) for the ant as "2-3 small clefts rounded off above," and the lenticular spots only faintly shown in fig. 2. The same appearance as that described by Rabl-Rückhard is found in the bases of the stalks in the bee, but the section represented in fig. 2 is too far back to show it. To imagine the figure, however, all that is necessary is to suppose the lenticular spots to be larger and united at their bases.

The lighter places between the spots are filled by the fibers of the mushroom body cells alone (fig. 17).

In the stalk my preparations show the existence of incoming fibers resembling the upper ones represented in fig. 28 more than any of the others. But details are not sufficient to enable one to determine their origin or the destination of their outer branches any better than, in fact not so well as, those entering the anterior root.

Very nearly the same thing may be said with respect to the fibers entering the inner root. Some of these appear to be connected with the central body later to be described, others seem to come from the opposite lower side of the brain. Their branches in the root are of the same general type as those represented in fig. 21, but the sub-branches are much shorter, more uniform, and end in a very much more compact head of branchlets. These of course cause the longitudinal banded appearance already mentioned.

Besides these six or seven groups of entering branches there are to be found numerous fibers irregularly branching over the surface or near the surface of the roots, which may also send small branches into them (fig. 22, Pl. XXI), and here may be noted a fiber seen in one section only that is of no little interest. Whether it belongs to any of the regular groups I am unable to say definitely, but think from its appearance that it must be a branch of one of the irregular fibers just mentioned. It is figured on plate XXI (fig. 25). It enters the right anterior root near its terminus from some little distance in the lateral part of the brain and is there of considerable size. But almost immediately upon entering it decreases in volume and after branching becomes connected with the neurites of the mushroom body cells. The junction appears as complete as though there existed here a veritable fusion. So fine are the fibers that the preparation also seems to show that the parallel fibers from the mushroom body cells have branches in this place. The latter condition cannot, however, be the true one, for in all other preparations, which are numerous, no such branching is shown. With Lenhossék (95) I agree that in general the bichromate of silver method, usually showing only silhouettes, is defective and very apt to mislead in the matter of fibrillar connections. But in the specimen in question viewed with a Leitz ocular No. 2, and objective No. 5, there is no more reason for doubting the continuity of the lines shown than there is in fibrils shown in preparations stained with hæmatoxylin or any other histological coloring matter. They are not superimposed, nor is there any reason for thinking them to be of tracheal nature.

When we consider the nature of the method used, it should not appear strange that fibrils in very close contact should be so impregnated with bichromate of silver as to cover up all evidences of separation. In fact it seems to me that such apparent evidences of continuity are to be expected, without, however, even raising a doubt as to the complete validity of the evidence obtained from the generality of terminations shown and from histo-ontogeny.

Before leaving the matter it must be noted that, although the figure given is a camera drawing made with the aid of careful focussing, it does not correspond with what appears when the camera is removed. Then the fibres *a*, *b* and *c* are seen to belong to the parallel fibres which are continued upwards beyond their junction with the fibrillar branches of the incoming fiber.

THE FUNCTION OF THE NERVE-CELLS OF THE MUSHROOM BODIES.

Ever since Dujardin (**50**) discovered the mushroom bodies and pointed out the relation between their size and the development of insect intelligence, nearly every writer on the subject of the hexapod brain who has referred to the matter of intelligence has recognized the fact. Leydig (**64**) thought them connected with the intelligence of the animal, but added that they also seemed to bear some relation to sight, or to the ocelli. Rabl-Rückhard (**75**) thought the same, except that he pointed out that Leydig's second supposition is incorrect, since in blind ants the bodies are found to be well developed, while the optic lobes and the nerves of the ocelli are absent. Forel (**74**) pointed out the same facts and added that the mushroom bodies are much the largest in the worker ant, and that those in the female are larger than those in the male. Two years later Brandt (**76**) affirmed the same condition to be true for the Hymenoptera generally. Berger (**78**) agreed with Dujardin and the rest. Dietl (**76**) was inclined to dissent, and Flögel (**78**) seemed to consider the roots and stalks as a framework (*Gerüst*) for the rest of the cerebral substance. Nevertheless the tabular summary of his study on the different orders that he gives at the end of his paper is of no inconsiderable value in showing the truth of Dujardin's inference, so far as comparative anatomy is able to do so. The physiological experiments of Faivre (**57**) and others, which have lately been repeated and perfected in the excellent work of Binet (**94**), are of great value in showing that the seat of intelligent control of an insect's movements is in the dorso-cerebron. Thus far, however, no attempts seem to have been made to determine experimentally the function of the mushroom bodies as parts distinct from the rest of the dorso-cerebron. Experiments are badly needed to complete our knowledge of the structures.

All that I am able at present to offer is the evidence from the minute structure and the relationships of the fibers of these bodies. This seems to be of no inconsiderable weight in support of the general idea started by Dujardin. For in connection with what was made known by Flögel and those before him and has since been confirmed and extended by other writers, one is able to see that the cells of the bodies in question are much more specialized in structure and isolated from the general mass of nerve fibers in those insects where it is generally admitted complexity of action or intelligence is greatest. Considering the calyx and the cells above it alone, one finds that according to Flögel neither are recognizable in the Hemiptera, that in Diptera (*Tabanus*) and Odonata (*Aeschna*) the bodies are recognizable from those in the neighborhood only by a slight difference in the size of the cells representing them; that in Lepidoptera the calyx-cup is very small or entirely absent, that in the Coleoptera (*Tenthrido, Cynips*) the calyx is not so extended as to be very well recognized as a cup, and that in the Orthoptera the lateral walls of the cup are either very small

(*Blatta*) or entirely absent (*Forficula*, *Acridium*, etc.); while in the Hymenoptera the calyx is folded upwards so as to give room for many more neural elements and connections.

If one considers the little that has thus far been made known by means of the bichromate of silver and the methylen-blue methods concerning the cerebral nerve fibers in other invertebrates, one finds that sensory stimuli are transferred to a number of irregular cells or fibers distinguished roughly by the term association fibers and from these transferred to motor or other fibers bearing efferent neural impulses. And from such a comparison it appears that in the groups of insects certain of these association fibers have gradually been set apart from the rest so as to render it possible for an entering stimulus to become an efferent impulse by taking a direct or an indirect course. In the former case the course is to be compared with the course of a stimulus producing reflex action in man. Later on it will be seen that the present assumption of the existence of fibers permitting such a course is fairly well founded. Thus a sensory impulse from an optic lobe or from an antenna may reach the fibers going to the mouth parts through possibly but one association fiber.

In the other case it may take a special or somewhat indirect course to and through the fibers of the cells of the mushroom bodies and from them reach the efferent fibers through the processes of one or more association cells. From those facts it seems far within the bounds of reason to suppose that the nerve cells of the mushroom bodies rendered so prominent by their specialization of form and position are the elements that control or produce actions that one distinguishes by the term intelligent.

An analysis of these actions is needed, but that is beyond the limits of this paper. Suffice it to point out that the experiments of Binet (94) and others show that when the connections between the dorso- and ventro-cerebron are destroyed the phenomena afterwards observed are similar to those seen in a pigeon or mammal when its cerebral hemispheres are removed. One difference is notable, namely, that the operation of eating in the case of the insect appears to be reflex ; for when one, vivisected as just indicated, is placed upon its food it begins and continues to eat. In the other case the animal must be fed. The various bodily movements of the insect, however, after a time take it away from the food, and once away it is wholly unable to return. Such insects when passing food even almost within touch of their palpi are wholly unable to change their course so as to secure it, although the movements of their palpi plainly show that its presence has affected them. Whether this would still remain the case when the vivisection is of such a nature as to allow sensory stimuli from the antennæ or visual stimuli to act through the reflex channels already mentioned is as yet unknown. From a consideration of the facts that I have pointed out and the facts demonstrated by comparative anatomy and embryology relative to the homologies of the antennæ one is warranted in expecting that the animal would still lack the power of *directing* its movements.

THE CENTRAL BODY.

This peculiar body was first made known by Dietl (**76**) as "the fan-shaped structure," and was two years later described by Flögel (**78**) as the central body, a term that has since been generally employed. It lies above and behind the ends of the inner roots of the mushroom bodies and is wholly composed of large nerve fibers and fibrillar substance, plus, doubtless some tracheal elements (figs. 2, 5, 6, 7, 8, 9, *c.b.*). A few of its connections I have been able to ascertain, but very much yet remains to be learned, so much in fact that any assertion as to its functions can be but little better than a mere guess. Viallanes (**87**) describes it as connected with all the surrounding parts of the brain, but that is an assertion too sweeping for the facts known to me after an application of the bichromate of silver, the copper-hæmatoxylin and platino-osmo-picric acid methods, and was much too sweeping for the actual facts known to Viallanes. Berger (**78**) recognized the body in *Dytiscus* as a lenticular body receiving a bundle of fibers from each side which entering broke up into its individual fibers, some going out anteriorly, some posteriorly, or, in short, as a center of disassociation.

The body throughout my diagrams and figures is distinguished by the letters *c. b.*

In the honey bee this body as a whole has a very much distorted spherical shape. In frontal sections the fan-shape described by Dietl and Berger is apparent (fig. 5), though the outline presented might be better described as reniform. Viewed from above or in horizontal sections it has a somewhat trapezoidal outline.

Internally, as shown by sections in the frontal plane, it is divided by a space filled with nerve fibers and tracheæ, into an upper and larger portion covering a lower and smaller portion. Both are seen in preparations by ordinary methods to be composed of fibrillar substance, but in frontal sections the lower usually stains more deeply (fig. 5). Antero-posteriorly the upper portion is also much the larger and considerably overhangs the other, partly covering two masses of fibrillar substance a little farther on to be described as tubercles.

Taken as a whole, fibers seem to reach it from or leave it in nearly all directions; but the two parts seem to be supplied somewhat differently. Those entering the lower are seen to originate from cells above the antennal lobes and upon reaching the lower lateral edges to take a transverse course below the body and send several branches upwards that subdivide arborescently producing a compact mass of branchlets that recall the arborescent and bushy terminations of the association fibers in the roots of the mushroom bodies (figs. 32 and 37). As in the case of these latter fibers, it is to the compact branching mass of fibrills that is due the depth of color so noticeable in preparations stained with osmic acid or with hæmatoxylin. Other fibers either pass out or enter from the fibrillar substance of the brain immediately in front, while branches from association fibers in the anterior region seem to enter the anterior end and the posterior lower end of this portion of the body (fig. 40, Pl. XXII).

In the upper portion the same arborescent method of branching also occurs, and gives rise to the wavy upper contour shown in figs. 5 and 6. But here the fibers originate from cells above the body in the median plane or from cells behind it and after passing behind the body enter the cleft separating the two portions, where many of them are gathered into bundles with an antero-posterior course. These recall the radiating bundles seen in the cups of the mushroom bodies. Other fibers also send their branches into it from its outer surface (Pl. XVIII).

Just behind the inner roots of the mushroom bodies large numbers of fibers seem to be given off, some of which pass downwards to the neighborhood of the œsophageal foramen, while others take a more lateral course (fig. 5). It is this appearance, which is very noticeable in preparations by ordinary methods, that doubtless led Viallanes to make the assertion referred to. When impregnated with bichromate of silver these fibers seem to originate from cells situated somewhere behind the central body and, after passing over its surface and sending branches in to it, to take the course described and shown so well in fig. 5. Some of them are probably the neurites of a group of cells whose dendritic branches form a commissure immedidiately behind the central body (fig. 9, Pl. XVI) and send their sub-branches into its posterior surface (Pls. XVII and XVIII, cells 5 and 6).

Another group of cells lying above the body in the median plane send their processes backwards over its surface and after sending a branch to what will soon be described as the fibrillar arch pass down behind and enter the space separating the upper and lower portions of the body and branch in the former portion (cell 2, Pl. XVIII). Fibers from cells situated behind the body and above the fibrillar arch also make the same connections. Another group of fibers originating from cells above the antennal lobes pass obliquely inwards to the space just behind the lower half of the body and passing upward in front of the glomerules end in the upper half. What connections are made by them I have not thus far been able to ascertain. No fibers passing between any portion of the central body and the calices of the mushroom bodies have been seen, and whatever indications have been noticed of connections with the inner roots of these bodies are of such a fragmentary and otherwise imperfect nature as to render their existence very doubtful. All that may be safely said is that it is connected with the fibrillar arch, possibly the ocellar glomerule, with the mass of association fibers immediately in front, with the lower lateral regions of the proto-cerebron, and with the trito-cerebral region forming the œsophageal commissure, where its fibers may possibly connect with others entering from the ventral cord, or with those belonging to the ventro-cerebron.

THE TUBERCLES OF THE CENTRAL BODY.

Behind the lower portion of the central body and partly covered by the overhanging upper portion (fig. 6, Pl. XV) are two small round, deeply staining masses of fibrillar substance to which Viallanes (87) applied the term of "tubercules du corps central." Just what their relations are to the central body, or what may be the origin of the fibrils forming them I have not been able to determine definitely. But from the fact that in thick unstained sections one can distinguish in the immediate neighborhood behind them masses of fibrillar substance of a similar globular appearance I am inclined to think them globules of the same kind and having the same or similar relationships as the latter. My preparations do not satisfactorily show fibers leading into or going from them. But there are indications that the mass of smaller glomerules is formed by terminations of the nerves from the ocelli very much as the so-called olfactory glomerules later to be described are produced by the terminations of the fibers from the antennae, and for that reason I choose to call them ocellar glomerulæ. This particular region of the brain along with the central body needs considerably more light than I am at present able to throw upon it.

THE FIBRILLAR ARCH.

This peculiar structure may as well be considered here, since it is connected with the central body, behind which and somewhat below the level of whose upper surface it lies. It is a rod-like mass of fibrillar substance that upon either side rises from but is scarcely connected with, the mass of fibrillar substance behind the union of the roots and stalks of the mushroom bodies and passes directly across the median line through the large mass of cells filling the posterior median furrow, thus forming a sort of commissure described by Viallanes (87) as "le pont du lobes cerebraux." It does not form a commissure, such as is ordinarily understood by the term, even though it connects the two lateral halves of the brain, and seems much better denominated by the term "gabelförmiger Körper" employed by Cuccati (88) or better still by the one that I have used. The central portion of the arch may be seen in figure 8, while in figure 9, several sections below, the pillars upon which it rises appear as two dark spots, one on either side of the enormous nerves from the ocelli.

In preparations treated with copper-sulphate and hæmatoxylin or by the platino-osmo-picric acid method of von Rath, large nerve fibers may be distinguished passing irregularly along its outer surface, and seemed to originate from cells situated on both sides of the brain near its ends. Viallanes (87) mentions fibers passing from it to the central body, a connection that as already intimated my preparations with bichromate of silver show to actually exist. A group of fibres from cells in the median plane above the central body send each a short branch that ends here in a tuft of branchlets (fig. 2, Pl. XVIII) and then continues on down into the central body as described when speaking of that structure. This short branch and its tuft-like ending without doubt represents the dendrite and the larger branch to the central body the neurite of the cells of this group. Other groups situated above and both before and behind reach the central body after branching in exactly the same manner. Viallanes (87) supposed that possibly the structure received branches from the ocellar nerves, but was far from being sure. Whether his supposition is true my preparations thus far made do not enable me to decide definitely, but from the fact that the nerves in question seem to begin to break up or become less numerous in this region and from a few indications in bichromate of silver preparations I am inclined to think that possibly his supposition will sometime be found to be true. What connections are made by the fibers mentioned as covering the outer surface of the structure, I am not prepared to say.

THE ASSOCIATION FIBERS OF THE PROTO-CEREBRON.

The fibrillar substance of the regions surrounding the bodies already described, or the rest of the central proto-cerebron, is composed of the association fibers coming from, and the tracts of fibers going to, these bodies, together with bundles of fibers entering it from various groups of cells and giving rise to a great number of irregular fibers to be classed under the general term of association fibers. In only a few cases have the cells from which these fibers originate been impregnated along with their fibers so as to make their relationships perfectly clear. What little has been learned I have endeavored to bring out in the diagrams that follow as well as in the camera sketches in the last two plates.

The fibers, as may be readily seen in fig. 1, take various courses, binding the upper, the lower and the lateral parts together. Fibers originating from cells above the antennal lobes pass up on the inner side of the anterior roots of the mushroom bodies and branch arborescently in the region just above them (fig. 31 and fiber 10 in the diagrams). Just below the root a small branch is given off that passes outward horizontally. Other fibers seen in preparations by the copper-hæmatoxylin method in front of the plane of fig. 1 seem to originate from cells above the antennal lobes, and, after passing upwards near the median line as rather large fibers, bend over the anterior roots of the same side and become lost in the fibrillar substance (Pl. XVII). The fibers of the cells in the median line under the edges of the calyx-cup and in front of the central body also seem to branch in this region, for I find no indications of their forming a chiasma and passing into the lower regions of the brain as described by Viallanes (84) for the Orthoptera, and by Cuccati (88) for *Somomya*. Other fibers of unknown origin (fig. 40, Pl. XXII), but of a very conspicuous appearance branch rather profusely in this region of the fibrillar substance and send branches back into the central body. Others bend over the inner roots and send branches upwards and across to the region immediately above the base of the anterior root of the opposite side (fig. 32, and fiber 50, Pl. XVIII). Another seems to arrive, (whether from over the top of the central body or from somewhere beneath the calyx-cup, is difficult to decide,) and branches near the junction of the two roots, one branch going toward the central body, the other straight downward (fiber 21, Pl. XVII). A similarly perpendicular fiber is also found on the outer side of the root (fiber 20, Pl. XVII). Still another (fig. 32) seems to arise as a small fiber from over the central body, passes downward to the opposite side, where it becomes much enlarged, and gives off numerous branches, these even passing out under the anterior root. It may possibly be one of a group of fibers (fiber 49, Pl. XVIII) originating from a group of cells near the fibrillar arch and passing directly forwards over the central body.

A horizontal fiber (fig. 22, Pl. XXI) originates somewhere at the side of the brain and after giving off several branches that spread out over the top of the anterior root ends in an arborescent system of fine branchlets in the upper part of the middle portion of the cerebron just across the root.

The fibers connecting the anterior and posterior region are most striking in appearance and are of considerable extent. One (fig. 30) apparently originates from cells in the region above and behind the antennal lobe and passes backward to one side of the median plane giving off a branch that subdivides and passes to the median anterior root, one passing up close to it and the other to a lower level. After giving off this branch it becomes very much smaller and passes on backwards, giving off several small branches meanwhile. Near the posterior wall it divides into two branches of small size, but of considerable length, the one going directly upward and branching among the ocellar glomerulæ, the other directly downward into the œsophageal commissure and the ventro-cerebron.

Another fibre (48) equally, if not more peculiar, is shown in figure 34. This appears to originate from a cell situated behind the inner root of the mushroom bodies (providing one may judge from the appearance of the fiber and the direction of its branches). Just behind the inner root and to one side of the base of the central body it becomes very much enlarged, gives off two relatively short branches and then one long one that passes up over the inner root and over the anterior root just in front of the junction of the two with the stalks, as shown by the dotted lines in the figure. Another branch a little further forward passes up to and branches in the fibrillar region to one side of the central body, while in front of this a number of short branches are given off that branch very profusely in the region to one side of the base of the central body. The main fiber continues forward to the neighborhood of the antennal lobes giving evidence of further branching, but on account of being either unimpregnated or cut off can not be traced farther.

The fiber shown in figure 35 is nearer the median plane and appears to come from the œsophageal commissure, passing upward and then directly forward under the central body, giving off along its course several branches that run back into or towards the commissure and then four very long though small branches that pass upwards in front of the central body ending, so far as can be traced, above the level of the top of the latter. One of the four passes farther forward and gives off a branch that turns back into the neighboring region to one side.

In figure 33 a more peculiarly twisted fiber (35) is shown, which was found in the lateral region of the proto-cerebron below and to one side of the anterior root and behind the optic body, near which it may possibly originate. Its base is at the right of the figure. It passes outwards for a short distance then backwards, gives off a branch that turns upon itself, divides again several times, some of the branches going upwards, the rest downwards and forward. There it passes downward for a short distance and divides into two large branches of almost equal size, one going backward, so far as traceable, apparently to the posterior region of the brain, the other forward, twisting above the parent stem and finally breaking up into a number of branches that terminate behind the central body.

The Deuto-cerebron.

THE ANTENNAL LOBE.

The antennal lobes comprise by far the larger portion of this division of the insect brain, especially so in the honey bee, and the rest of the Hymenoptera for that matter, where the remaining small portion is so fused with the proto- and the trito-cerebron as to leave little or no trace of separating boundaries.

Considering first the antennal lobes, one may say that sections cut in various planes show that each lobe is composed internally of a nearly spherical mass of fibrillar substance connected with the rest of the brain by a small neck of the same substance and surrounded on all sides by a large number of cells, some of which belong to it and some to the proto- and the trito-cerebron, and fill in the deep spaces between it and these two parts. Inside of this sphere and near or composing its periphery one finds small globular masses that by any of the ordinary methods of staining take a much greater depth of color than the more internal part, and in them one recognizes the great non-nucleated cells of Leydig (**64**) and Rabl-Rückhard (**75**), which were first more correctly described by Dietl (**76**) as olfactory bodies. Flögel (**78**) claims the honor of pointing out their true significance, for, he says, he called attention in an unpublished communication to the Kieler Physiologische Vereins, July 30, 1874, to the fact that they are not cells. Fig. 1 shows the bodies or glomerulæ very plainly.

Between them even in ordinary preparations processes from the bordering cells may be traced to the inner fibrillar substance, but it is doubtful whether branches entering them may be seen in such preparations. Cuccati (**88**) regarded them along with the rest of the mass as made up for the most part of branches of these processes that by subdividing formed with whatever other fibers that might be there a sort of net work. The only difference that he supposed to exist between them and the central portion of the mass was in the greater fineness of the meshes of the net. But while his supposition with respect to the relation of the glomerulæ to the surrounding cells is correct and even though some of my preparation are so strongly impregnated with bichromate of silver as to present considerable resemblance to a meshwork, I am inclined to believe other preparations showing a tuft-like system of branching illustrate the true condition (fig. 10 and 16, Pl. XXI), and that the idea of connection by contact holds as well here as elsewhere. As already pointed out cases might occur in such preparations in which the darkened fibers might appear perfectly continuous, so as not even to be explained by Lenhossék's suggestion of a silhouette of superimposed fibers, and still not be fused or continuous. Happily such deceptive appearaces seem to be rare except in too heavily impregnated preparations.

When impregnated with bichromate of silver the glomerules strongly recall the appearance of the olfactory glomerulæ figured by Retzius (92) for the vertebrates, and may perhaps be very well called olfactory glomerulæ. But exactly what their relations may be with the surrounding cells and the incoming fibers I am not able to say definitely. In none of my preparations is an unbroken connection shown between them and the cells clothing the lobes, the fragmentary appearances, however, amply warrant the supposition that the processes of the cells make their way between the bodies and after passing some distance in the middle mass of fibers send a branch into one of the glomerulæ and another one into the proto-cerebron (fig. 10, 16 and 24, Pl. XXI). Whether the process from a single cell sends branches to more than one body does not appear, but if one may judge from the form of the cells of the mushroom body, probably it does not.

THE ROOT OF THE ANTENNO-SENSORY NERVE.

Besides the fibers just described there are to be distinguished two other kinds. One of these composes the root of the antenno-sensory nerve, which in preparations with osmic acid or by the copper-hæmatoxylin method may be traced from its entrance into the lobe on the lower anterior surface nearly to the posterior upper surface. Throughout its course it gives off numerous fibers and branches. My preparations by the better neural method that are favorable for tracing it are not numerous. Fig. 16 represents one in which the fibers shown are all that are impregnated in this region. Here a fiber is seen coming in from the nerve and at some distance from its entrance bending aside to a glomerula from which another fiber passes out and then on towards the proto-cerebron. The other fiber soon after entering breaks up into three branches one of which terminates in a glomerula. The tuft-like termination was not seen when the drawing was made, but after the latter was fixed to the plate a re-examination of the specimen brought it to light, but with scarcely sufficient distinctness to be drawn with a camera.

If one is to credit, as one must, the long list of writers since the time of Newport dealing with the antennæ anatomically and physiologically, one must conclude that these organs have at least two, and in many cases, if not always, three different functions. That they are both tactile and olfactory has long been known, and recently Child (94) has brought forth very good anatomical reasons for their being also auditory. Such being the case one might expect to find as many different kinds of terminations in the antennal morula.

There is a striking resemblance between the tufts forming the glomerulæ and those forming the olfactory glomerulæ in mammals as described and figured by Retzius (92 *a*); and, since in the ventro-cerebron where sensory fibers from the oral nerves undoubtedly terminate no such glomerulæ are found, one may be very easily led to the conclusion that the glomerulæ are for olfactory terminations. But I am unable to produce evidence of other terminations and must for the present conclude that the glomerulæ are formed by the terminations of all kinds of fibers from the antennæ. This conclusion is supported by the fact that the tubercles of the central body, in which fibers from the ocellar nerves apparently terminate, and the ocellar glomerulæ have a very similar appearance.

Another kind of fiber is shown along with its cell in fig. 15. This was found in the posterior ventral regions and bears a slight resemblance to cells and fibers that are undoubtedly of efferent nature. It may be a portion of such a one that by branching among the olfactory glomerulæ as indicated in the figure makes a reflex course from the afferent antennal fibers to the antennal muscles. Still it may be only an association fiber of which there may be many in the antennal lobe, though their appearance does not distinguish them as such as readily as in the case of the association fibers of the rest of the brain. Whatever other fibers there are that might be classed as such are of small size. Some of them appear to pass into the neck already spoken of as connecting the lobe to the rest of the brain.

THE ROOT OF THE ANTENNO-MOTOR NERVES.

The small internal antenno-motor nerve supplying the antennal muscles within the head appears to be but a branch of the larger one passing on to the antenna and with it has a common root. In sagittal sections treated by ordinary methods this may be readily followed on the lower side of the antennal lobe and somewhat to one side of its median line as a bundle of medullated fibers that passes through the group of cells filling the lower space between the œsophageal commissure and the globular mass of fibrillar substance of the lobe. It penetrates the fibrillar substance here and may still be followed through an inward, backward, and upward course for a considerable distance. Gradually it decreases somewhat in size or loses its fibers, and is finally untraceable. In such sections of brains impregnated with bichromate of silver the fibers are frequently found impregnated and then form a large bunch of branching fibers spreading out in the commissure taking in the trito-cerebron and to a slight extent the ventro-cerebron. Branches also pass upwards into the proto-cerebral region. In one case of a thick frontal section embracing the posterior part of the antennal lobe and nearly all of the proto-cerebron behind its plane a single fiber considerably smaller for a portion of its length can be seen above the level of the lobe, as shown in Plate XVII on the right where an attempt was made to reproduce it. Below it decreases in size and joins several other fibers, the whole of which were not impregnated, and forms with them a band of fibers traceable down behind the lobe until hidden by the intervening strongly impregnated glomerulæ. As this band occupies the same position as the antenno-motor root seen in ordinary preparations I take it for granted that the fiber is motor and belongs to this nerve. The large part of the fiber inclines posteriorly in passing upward, terminating, so far as traceable, very close to the inner root of the mushroom body at some little distance from the median line. Three of its branches are impregnated. The lower one passes forwards towards the inner side of the antennal lobe and does not subdivide. From this fact and its apparent destination I have supposed that its cell of origin is situated among the cells filling this space between the lobe and the commissure. Higher up two branches are given off nearly together, one passing internally towards the median line, and the other, which is much longer, passing outward and downward in the trito-cerebral region and branching. But here it is obscured by other details. A short distance above this another long branch is given off. This goes diagonally backwards to the posterior-lateral angle of the proto-cerebron ending in several small branches.

In other sections made in the horizontal plane fibers of a similar appearance were found taking a horizontal course and passing apparently beneath the antennal morula (Pl. XIX). These branch, as shown in the diagram, much more profusely than the other one just described, a fact that is doubtless due to their better impregnation. One sends a long slender process, or rather continues as such, backwards to the layer of cells clothing this part of the brain. But whether it actually arises from any of them I am unable to say. It is not impossible, and, if one considers the fiber shown on the opposite side of the plate, which after branching profusely and irregularly sends off a slender process in the direction of the antenno-motor nerve, it may not seem improbable. The details are not sufficient to settle the matter, however, and until they are shown to exist, I shall be inclined to believe that probably all the cells giving rise to the antenno-motor nerve are situated close to or in the lobe on the anterior side of the brain. Fig. 39 represents a camera drawing of the two fibers just described and also another from the next section above them.

The Dorso-Cerebral Fiber Tracts.

THE CONNECTIONS WITH THE OPTIC LOBES.

Tracts of fibers passing from the optic lobes into the central part of the proto-cerebron were early recognized by Berger (78) and Bellonci (82), but the interpretations of these authors are very largely incorrect. Viallanes (87,88) seems to have described most of them much more correctly, and the same may be said of Cuccati (88), so far as I am able, without an actual study of sections of *Somomya*, to homologize his results with my own. Certain peculiarities are figured and described by him that render a comparison difficult.

Before describing the connections it should be noted that the masses of fibrillar substance forming what are usually known as the optic ganglia, but which are much more properly denominated fibrillar masses, are seen in frontal or horizontal sections treated by ordinary methods to be composed of two outer layers of densely staining masses, and very much resemble in form two meniscus lenses placed one within the other. The space between them is filled with a loose mass of fibers, and the whole is so placed as to have its convex surface directed outward and its concave surface inward.

The inner of these masses lies in hexapods close against the central proto-cerebron, being separated from it by a layer of cells and a few bands of fibers. In other words there is no optic nerve such as is found in the Crustacea. The attempts by the earlier writers to distinguish an optic nerve were long ago shown by Viallanes (87) to be more or less unsuccessful, since there is not one but several connecting tracts. These with the optic lobe sufficiently removed from the rest of the brain, might, however, produce the homologue of the crustacean optic nerve.

The Anterior Optic Tract.

Even in ordinary preparations there are indications of fibers passing radially or nearly perpendicularly to its two surfaces, through the inner fibrillar mass. Emerging from the inner surface these are gathered into two bundles, the larger of which passes forward, and slightly downward along the outer surface of the central proto-cerebron and finally terminates in a small oval body called by Viallanes (87) the optic tubercle, situated immediately above the antennal lobe and to one side and below the terminus of the anterior root of the mushroom bodies of that side. In preparations with bichromate of silver the bundle is often very prominently shown, and in addition also the arborescent terminations of its fibers in the optic body, as shown in the diagrams that follow. This body in the bee is divided into a large inner mass and a very small outer mass, and into the latter some of the fibers of the tract send each a small branch before passing on to the larger body.

Other fibers apparently arising from cells in the immediate neighborhood also branch in the body and connect it with other parts of the brain. One group passes to the opposite side and appears to terminate in the opposite optic body. Others pass backward, but no tracts appear to connect it with the mushroom bodies, although individual fibers are often found going in that direction.

The Postero-superior Optic Tract.

As just indicated, the fibers emerging from the convex surface of the inner fibrillar mass divide into a large and a small bundle. The latter may be considered the postero-superior optic tract, which seems to have escaped the notice of Viallanes (87, 88). It may be easily traced in preparations either by the copper-hæmatoxylin method or by the platino-osmo-aceto-picric acid method of von Rath, and after leaving its larger companion, which is almost immediately, it passes upward along the outer surface of the central proto-cerebral mass, and joining the antero-superior tract, to be described a few lines further on, takes an inward course until, arrived close to the stalk of the outer mushroom body, it leaves this other tract and passes behind the stalk close to the junction of the latter with the calyx. Whether any of its branches pass into the calyx here I am not able to say definitely, but apparently they do. In preparations with bichromate of silver some at least of its fibers may be followed across the intervening space to the opposite side of the stalk of the inner mushroom body. Whether any of them continue on into the superior commissural tract my preparations thus far made do not show.

The Antero-superior Optic Tract.

This as described by Viallanes (87) and Cuccati (88) starts from the outer fibrillar mass. Instead of originating like the two tracts just described from the radiating fibers of the mass, it arises from the fibers filling the space between its two lenticular portions. These fibers are gathered into a bundle and leave the mass at its antero-superior edge. Passing backward and inward through the intervening layer of cells, the bundle reaches the outer surface of the central proto-cerebral mass, then turning upward joins the postero-superior bundle. Just before reaching the stalk of the outer mushroom body it leaves its companion and passes in front of the stalk, close to its junction with the calyx, to the space between the two stalks where its fibers branch, one group passing into the outer, the other into the inner calyx. In one preparation I was able to determine the cells of origin of this tract and to follow it through several sections to its connection with the optic mass. According to the facts shown in this brain impregnated with bichromate of silver the description should be reversed and the union of the tract with the optic mass be spoken of as its terminus, for the cells from which it originates comprise a small group on the supero-anterior-lateral surface of the central proto-cerebral mass and send their processes as a bundle of fibers almost directly backward to the space between the two stalks, whence a branch passes into the calices and another to the fibrillar optic mass, as described.

The Antero-posterior Optic Tract.

This has been well described by Viallanes (87) in his memoirs on the hexapod brain and also by Cuccati (88) in his paper on *Somomya erythrocephala.* Like the tract last described it is formed from the fibers coming from the central portion of the outer optic fibrillar mass, which it leaves at the same point. Leaving the antero-superior tract at the optic mass it takes a backward and somewhat inward and downward course through the intervening mass of cells, passing over the anterior optic tract and between the inner optic mass and the central portion of the proto-cerebron and turns into the latter at its postero-lateral lower angle. After entering here the fibers separate from one another and branch, but may be followed for some distance towards the median line. Where its cells of origin are to be found I cannot say definitely. But in certain of my bichromate of silver preparations I have seen processes from cells in a group near the starting point of the tract entering the fibrillar mass, and it is not improbable that they are the cells of origin of the fibers of this tract.

*The Posterior Optic Tracts.**

Of the remaining tracts connecting the optic lobe with the central proto-cerebral mass, there are several; but before pro-

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*The following shows to what extent my results correspond with those of Viallanes (87) who found four and I five tracts connecting the optic lobe with the central cerebral mass:

A. Connections with the outer optic mass.
    1. Faisceau supéro-antereur =
    Antero-superior tract *mihi.*
    2. Faisceau supéro-postereur =
    Antero-posterior optic tract *mihi* .
B. Connections with the inner optic mass.
    3. Faisceau inféro-antereur =
    Anterior optic tract *mihi.*
    4. Faisceau inféro-postéreur, 2 tracts =
    2 of my posterior tracts.

In his work on the grasshopper (88) he was unable to find the two tracts from the outer mass, while from the inner mass he found arising two tracts, one corresponding to my anterior optic tract, the other—his cordon commissural—to my lower optic commissure.

ceeding with their description it should be noted that the inner optic mass is so turned as to bring its posterior edge much closer to the central brain mass than its anterior margin. It is at this posterior margin that the entrance to the space between its two lenticular portions is situated.

From this opening emerge a large number of fibers gathered into several bundles, the most of which terminate in the adjacent posterior lower portion of the central proto-cerebron.

Of these bundles Viallanes (87) distinguished four, and Cuccati (88) seems to have found some of them in *Somomya.* The inner optic region of this genus, as shown by the latter author, differs so much from what I find in the bee or have seen figured or described elsewhere that comparisons are very uncertain. What he calls the ovoid body (eiförmige Körper) doubtless corresponds to the inner optic mass as generally met with, but what may be the homologue of his S-form body I am at a loss to know unless it may possibly be the outer lenticular portion considerably separated from the inner one. But in case that were true, there would be an anomalous condition of fibers from the concave face of the outer optic mass passing through the space, a condition of affairs that is not true in the case of the bee nor probably in any other hexapod. He also figures and describes several tracts of fibers that apparently correspond to some of those to be described here a few lines ahead, but as originating from the outer surface of the S-form or of the ovoid body, which, I take it, is equivalent to describing them in the bee as arising from the outer surface of the inner optic mass, and this is not true.

But to proceed with the optic tracts, there may first be described one, noted by both Viallanes (87) and Cuccati (88), leaving the inner margin of the inner lenticular body and passing into the central proto-cerebral mass a little above the point of entrance of the antero-posterior tract and continuing thence as a loose band of fibers across the posterior region of the brain and below the fibrillar arch to the inner optic mass of the opposite side, thus forming what may be termed the upper optic commissure. It does not pass directly across but is arched slightly upward. It may be followed with little difficulty in ordinary preparations, and I have several times found its fibers impregnated in brains treated by the bichromate of silver method. Whether its fibers branch in the central brain I cannot say definitely. There are indications, however, that they do, and further, that their cells of origin may be situated among those forming the mass of cells behind the central body.

Below this, in a plane taking in the anterior optic tracts and the optic body, and a little below the lower level of the inner roots of the mushroom bodies, there are three tracts, which may be seen in figure 10, Pl. XVI. These differ considerably according to the direction of the plane in which the section is cut, and also seem to differ somewhat in different individuals. In another brain from that from which the figure was taken there is a bundle that is not shown in the figure. This is described by Viallanes (87) as divided into a thicker and a thinner bundle, which is the case here. Both emerge from the inner edge of the inner lenticular body and terminate in the neighboring central region after penetrating no further than do the posterior two of those shown in the figure. The anterior of the two is considerably the larger and from its manner of staining may readily be considered as composed of many very fine fibrils. The other is composed of fewer and coarser fibers and seems to arise more directly from the space between the two lenticular bodies.

Below these are two more bundles, or the posterior two shown in the figure. These resemble the one just described and arise and terminate similarly.

At a slightly lower level is the last of the series, which arises from near the margin of the inner lenticular body and passing directly into the central mass, bends slightly downward and then upward again to its former level and passes on as the lower optic commissure to the lobe of the opposite side. This is a much more compact and well marked bundle than the upper optic commissure and seemingly gives off no branches, although further study will probably show that it does. In one preparation by the copper-hæmatoxylin method in which the sections are in the horizontal plane I find fibers above it on each side of the brain that seem to run down to and join it in its middle portion. But in bichromate of silver preparations, although I have several times found some of its fibers impregnated I have not found sufficient evidence to warrant my saying that it branches. Just where its cells of origin are I have not been able to determine.

THE DORSO-CEREBRAL COMMISSURES.

Of the bands of fibers connecting the two lateral halves of the dorso-cerebron there are at least six, and of these two have already been noted in connection with the optic tracts. Some of them have long been known, but on account mostly of a lack of proper neurological methods have seldom been correctly understood. Viallanes (87,88) seems to have made fewer mistakes than any other writer who has considered them.

The Superior Dorso-cerebral Commissure.

This band of fibers crossing the median line of the brain above the central body and between the two inner stalks of the mushroom bodies (fig. 2) was noted by Dietl (76) and Berger (78) and considered as connecting the two optic lobes, a mistake perpetuated by Bellonci in his study of *Grylotalpa*. The fibers are brought out very prominently by most of the ordinary methods and I have repeatedly found them impregnated in brains treated by the bichromate of silver method. They are all of small size and non-medullated. By a comparison of frontal and horizontal sections (figs. 2 and 7) they are seen to form a band whose broadest extent is in the antero-posterior direction, and to be divided at either end into two parts—a division that can sometimes be distinguished throughout the length of the commissure—one of which passes behind and the other in front of the stalk. There does not seem to be a crossing of the fibers, but those passing in front of one stalk also pass in front of the other. In preparations with hæmatoxylin or with osmic acid the halves may be traced in horizontal sections around the inner stalks to the space between these and the outer ones and apparently into the calices. Since the tracts from the optic and antennal lobes also enter this region, very much care is necessary in distinguishing the different tracts, but since they fuse to some extent upon entering the calices, it is impossible to follow any one of them singly. Viallanes probably correctly interpreted this bundle as a commissure between the two pairs of mushroom bodies. There is apparently very little probability of any of its fibers reaching the optic lobes, though none of the methods employed by me have thus far demonstrated conclusively that they do not, nor have I been able to determine their exact terminations in the calices nor the location of their cells of origin. In preparations with hæmatoxylin and with osmic acid processes from the cells behind the inner side of the inner stalks have been traced upwards and forwards, apparently passing into the commissure as it passes around the stalks, but no such fibers have been found impregnated in brains prepared according to the bichromate of silver method. This negative evidence is not, however, at all conclusive since a sufficiently large number of brains have not been treated.

The Anterior Commissure.

The small band of fibers composing this commissure was first discovered by Viallanes (87) as connecting the two optic bodies. It may be followed in ordinary preparations without much difficulty from the posterior margin of one optic body across the anterior region of the brain and below the roots of the mushroom bodies to the optic body of the opposite side. Apparently its fibers originate from the group of cells immediately inside of and below the body. The processes from the cells seem to pass upward, and after sending a short process into the body where as seen in bichromate of silver preparations, it branches very profusely, and then passes across the median line. I have not been able to determine exactly its termination on the opposite side or whether it or any of its branches penetrate the optic body here. One bichromate of silver preparation where the fibers of the tract are most completely impregnated is inconclusive from the very fact of the extent of the impregnation. From it one might conclude that branches pass into the optic body, but the greater number into the region immediately behind it.

The Optic Commissures.

The two tracts of fibers forming the one the upper and the other the lower optic commissure have already been described in connection with the optic tracts. As noted there, I am unable to say definitely whether either give off branches to the brain in passing, and it may be added here that I have no evidence to show that a single nerve cell makes the entire connection between the lobes, if such be actually the function of the tracts. The question needs much further study.

The Inferior Dorso-cerebral Commissures.

The two groups of fibers connecting the lateral halves of the dorso-cerebron immediately above the œsophageal foramen have been variously misunderstood. They are shown in fig. 10 where they appear as two short tracts in front of the larger lower optic commissure. The anterior of the two was supposed by the earlier writers to connect the antennal lobes, and even the olfactory glomerulæ of one side with those of the other. Of such a direct connection I find no evidence whatever, though without doubt the two commissures may be considered as connecting the two deuto-cerebral lobes. In ordinary preparations sectioned in the horizontal plane both commissures are found immediately above the foramen, in fact almost bordering upon it, and may be traced for a short distance into the fibrillar substance of either side where the fibers curve slightly downward and separating from the tract branch and disappear. In frontal sections the fibers may be followed a little farther than in those cut in a horizontal plane. In fig. 5 one of the tracts may be seen though somewhat indistinctly.

In bichromate of silver preparations, although I have frequently found commissural fibers impregnated, I have not found sufficient details to warrant a definite assertion as to the exact relation of the tracts to the rest of the brain, nor as to the situation of the cells giving rise to their fibers. What details there are, however, indicate that the anterior tract connects the two regions, which may be called deuto-cerebral, immediately behind the antennal lobes. If it in any way connects the two lobes or their glomerulæ, it is only by means of intervening association fibers. But such a connection is doubtful from physiological reasons. It seems much more probable that the commissural fibers by the aid of association fibers of one side, should connect the glomerulæ of that side with motor fibers of the other. Still the other supposition is not impossible, and one should rather follow the maxim of Hunter, "do not think, but go and see", and wait until facts, physiological or otherwise, are obtained to decide the matter.

The fibers of the posterior tract, which is separated from the other by the ascending tracts from the antennal lobes to the mushroom bodies, connect more posterior parts of the brain. The fibers shown in fig. 38, apparently belong to this tract since at the median line they occupy the same position. Here they are obscured by a mass of precipitate filling the roof of the foramen, but since there are no other fibers impregnated here, there can be little doubt that the fibers of the opposite side are a continuation of them. The branching and larger portion of them is found in the posterior lateral lower angle of the brain, and it is possible that they may originate from cells in this neighborhood. One of them, it may be noted, sends a slender branch forwards toward the antennal lobe.

THE ANTENNO-CEREBRAL TRACTS.

The existence of tracts of fibers passing upwards from the antennal lobes into the proto-cerebron has been known ever since Bellonci (82) published his account of them in *Gryllotalpa*. But of the three pairs of such tracts he seems to have distinguished but two, and certainly misunderstood the relationships of these. For he describes them as antenno-optic connections passing from the antennal lobe upwards into the proto-cerebron and to the optic lobes by way of the superior commissure, which he recognized with Dietl and Berger as connecting the optic lobes. The same error was committed by Cuccati (88) who found in *Somomya* what is unquestionably the homologue of the inner tract to be described a little farther on, and which is also the main tract discovered by Bellonci. Viallanes (87) found the tract in the wasp and for the first time described it correctly.

In certain of my preparations of the brain of the bee by the copper-hæmatoxylin method these antenno-cerebral tracts are very distinct and very easily followed. This is the case in sections cut in any of the three planes.

The Inner Antenno-cerebral Tract.

The one first to be described is the largest and also the one first discovered. It arises in the neck of fibrillar substance connecting the antennal morula with the rest of the brain and ascending upwards, inwards and backwards (fig. 2) it passes between the two ventral commissures of the dorso-cerebron (fig. 10). Thence curving backwards somewhat it passes behind the root of the mushroom bodies and the outer hinder margin of the central body and in front of the fibrillar arch (figs. 8 and 9) to the level of the superior commissure, behind which it may be seen in section in fig. 7. From here it bends forward and passing around in front of the inner stalk of the mushroom body enters the inner calyx at its junction with the stalk and on the antero-lateral side of the latter.

In bichromate of silver preparations I have several times found the fibers of the tract impregnated for nearly their entire length. And in many cases different portions of the tract in successive sections were so well impregnated that their superimposition was a very easy matter. Fig. 24 represents the superimposition of three such sections and shows the tract from the calyx above to the inside of the antennal morula below. In no case have I found fibers from a glomerula passing into the tract, but the arrangement of the many fiber-fragments that have been seen almost conclusively demonstrated that they enter it (fig. 24). The fiber from the glomerula shown in the figure offers a very good example.

Nor have I found the fibers in cennection with cells, but, considering their connection with the glomerulæ as practically demonstrated, it may be remembered that very good reasons appear for considering the glomerulæ as connected with the cells clothing the morula, and from this it is fairly evident that the same cells give rise to the fibers of the tract. A little further evidence will appear in connection with the outer tract.

The Middle Antenno-cerebral Tract.

The next tract to be considered is the smallest of the three and arises as a branch of the one just described at a point just above the level of the ventral commissures. It takes an outward course behind the mushroom body (fig. 6) and continues upward to the region behind and between the stalks and then bending forward somewhat passes into the outer calyx.

This seems to be the branch figured by Bellonci as passing outward into the supposed tract between the optic lobes. In several of my bichromate of silver preparations it is very readily followed.

The Outer Antenno-cerebral Tract.

This tract is of considerable size and originates, as shown in bichromate of silver preparations (fig. 24), from cells above the antennal morula. From the morula it passes backward and outward towards the side of the central brain mass and gradually turning upwards passes behind, but in contact with, the lower optic commissure (fig. 6) and finally reaches the outer dorsal surface of the fibrillar substance and there, joining the antero-superior optic tract, passes in front of the outer stalk into the calyx above. Whether any of its fibers continue to the other calyx or not, I cannot say.

In some frontal sections there appears to be given off from this tract below the lower optic commissure a small bundle of fibers that curves outward and apparently joins the commissure. But in horizontal sections it seems to follow the commissure to a point near the outer surface of the fibrillar substance, where it turns abruptly forward and enters the mass forming the antero-lateral lower angle of the central cerebral mass.

THE DORSO-VENTRAL TRACT.

Five tracts of fibers have thus far been described as entering the calices of the mushroom bodies and there still remains another. This was first brought to my notice in a frontal section of a brain impregnated with bichromate of silver, and was subsequently recognized in a similar section of a pupal brain treated by the copper-hæmatoxylin method. It begins as a small band of fibers in the region between the two stalks, where branches of it enter both calices, and passes downward beneath the cells clothing the posterior surface of the brain to the œsophageal foramen, then continues anteriorly along the roof of this so as to reach the opposite side of the brain near the anterior surface. In its passage along the roof of the foramen its fibers send branches into the side from which the main fibers came, and these form an arborescent termination among branches of fibers coming from the ventro-cerebron and the ventral cord. Since these latter fibers cross the median line above the foramen anteriorly, the passage of the tract to the opposite side brings it into close relation with them along their whole extent along the roof of the foramen. This relation is best shown in plate XX, which shows two fibers of the tract as seen in a single section. The cells of origin of the tract have not been seen. But sufficient has been determined to show in what close relationship the cells of the mushroom bodies stand with the ventral nervous system.

The Ocellar Nerves.

In the bee the ocelli are situated close together, and as a consequence their so-called ganglia are contiguous and their nerves to a large extent fused. The nerve from the median ocellus passes downward and backward between the two inner calices and fusing with the nerves from the lateral ocelli forms with them a single mass that divides to pass around a large trachea piercing the brain in the median line between the calyx cups. Immediately below this the fibers again come into close contact, but at a little lower level some of those coming originally from the median ocellus separate from the rest and follow a course that takes them down in front of the fibrillar arch to terminate finally, as apparently shown in copper-hæmatoxylin preparations cut sagittally, in the tubercles of the central body.

The others form a broad band of fibers passing down behind the fibrillar arch to which, as suggested by Cuccati (88), some of them may give off branches. Certainly some of the smaller fibers cannot be traced below this level (Pl. XVI).

Both the anterior and the posterior groups are composed of two kinds of fibers, one enormously large and the other of ordinary size. The large fibers are very noticeable in preparations by the copper-hæmatoxylin method from the fact that they stain but slightly and thus appear as light colored spots in a deeply colored surrounding mass of cells (fig. 7-9). Similar results are obtained with von Rath's platino-osmo-aceto-picric acid mixture. The unstained fibers look very much like sections of tubes. But in preparations treated with Weigert's hæmatoxylin, or in those after-stained with fuchsin the fibers stain more or less deeply and thus demonstrate that they are at least not empty tubes. Even in preparations by my copper-hæmatoxylin method staining sometimes takes place. In such cases the inner mass appears in section to be shrunken away from the surrounding fibrillar wall, but remaining connected with it by slender filaments. This would seem to show that they are not formed upon exactly the same plan as other nerve fibers. A careful histological study of their structure is necessary.

The nerves thus constituted may be followed for some distance below the fibrillar arch, but seem to branch and gradually decrease in size. This is noticeable in the figures, where in fig. 7, the anterior nerve appears with three large fibers and at a considerably lower level (fig. 9) there is but one. The fibers of this nerve soon become untraceable and appear to pass into the fibrillar arch and the ocellar glomerule beneath.

Some of the fibers of the other two nerves seem to terminate in the same way, but a large number of the larger fibers continue downward, as seen in both horizontal and frontal sections, until they reach the neighborhood above the œsophageal foramen, where they separate. Some seem to terminate in this region. The others come into close contact with the hinder surface of the brain and pass on downward in the upper surface of the œsophageal commissures to the ventro-cerebron, whence they pass on backward along the dorsal surface of the ventral cord, thus effectually disproving Binet's (94) assertion that there are no large fibers in the dorsal region of the cord comparable to those found in crustacea. In many cases I have found these large fibers of the cord in bichromate of silver preparations passing along the dorsal surface of the ventro-cerebron on into the region just below the level of the central body as shown in Pl. XX. What their significance may be I do not at present undertake to say. Had Binet persevered longer in his trial of either of the two methods preeminent in the study of the nervous system, he probably would have found them. But while the existence of the large fibers is beyond question, there is still a chance that my description of them as coming from the ocelli is erroneous, for the reason that I have not been able, in specimens prepared by the bichromate of silver method or by any other, to follow a fiber through an unbroken or unsectioned course from the ocellar ganglion or the upper portion of an ocellar nerve to the ventral cord. Yet impregnated fibers have been followed without interruption from the copper-the level indicated above, and ʌ the large fibers have been carefully traced through sections treated according to my copper-hæmatoxylin method. It should be noted that Cuccati (88) also traced them in *Samomya*, as I have done here, into the ventral cord. Viallanes (87, 88) did not succeed in following them below the fibrillar mass behind the inner root of the mushroom bodies.

THE FIBERS FROM THE BRAIN TO THE OCELLAR GANGLIA.

Besides the fibers just described as constituting the ocellar nerves there may, in preparations by the bichromate of silver method, be distinguished others of an efferent nature (fig. 42, Pl. XXII). These may be traced from below the level of the calices into the ocellar ganglia where they branch arborescently. None are large. Where they originate or what may be their fibrillar connections within the brain, I have not as yet been able to learn. Not many preparations were obtained showing them passing out of the ganglia, and in fact only one in which they could be traced from below the calices, and from this the two fibers of the figures were taken.

As there are no muscular structures in the ganglia, their function is doubless to control the action of the pigment of the pigment cells.

The Commissural and Ventro-cerebral Region.

Since in the case of the bee they are so closely bound to it, the parts composing the œsophageal commissures may be considered along with the ventro-cerebron.

As already pointed out, the trito-cerebral lobe is very much reduced and is mainly distinguishable externally by the labral nerve. This is not far behind the internal antenno-motor nerve and its root may be traced for a short distance into a small lobe just inside the neck of the antennal morula. Fig. 2 is just a little too far forward to show it, but a section of the nerve may be seen on the left at its point of entrance. In bichromate of silver preparations the fibers entering from it very quickly form a bushy tuft of branches just beneath the root of the antenno-motor nerve. Some of these reach back into the ventro-cerebron.

The roots of the other oral nerves may be followed in ordinary preparatious each as a light band of fibers that passes upward above the point of entrance of the nerve and then bends inward towards the median line and ends in a roll of fibers that is apparently much more easily distinguishable in other forms than in the bee, and which Binet (94) calls the ventral column. This passes backward into the ventral cord. The two roots that Binet describes for each crural and each ventro-cerebral nerve in *Cerambyx* and other beetles I do not find in my sections of the bee's ventro-cerebron. This may be due to their being fused, but the attention that I have given this portion of the brain is as yet small in comparison to that given the dorso-cerebron.

In bichromate of silver preparations some of the fibers entering from the nerves very quickly break up into branches, but reach a little above the lower half of the ganglion. In a few cases the roots were found impregnated for nearly their whole extent and did not appear to give off many branches to the ventral region. In one case two cells in front of the mandibular nerve were each found connected with a fiber that passed out through the nerve, but whatever inner branches they may have had were not impregnated (Pl. XX). In another case a large cell was found on the lower lateral side of the brain sending a process into the region above, where it gave off a very extensive small branch (fig. 36). Near the broken end of the fiber another that is not shown in the figure began. This was apparently a continuation of it. The appearances of the section indicated that the fiber had been cut on account of its forming a slight bend outside the plane of the razor. The second fiber turning forwards gradually became swollen distally and then decreasing passed as a smaller fiber into the root of the antenno-motor nerve. The latter cell then is certainly motor, and taking for granted what has already been fairly well demonstrated by other observers; namely, that cells in the brain sending their neurites out of it are motor or bearers of efferent neural impulses, and the fibers entering from external cells are sensory, it is just as surely true that the other cell is of a motor nature.

This ventral position of motor cells here tends to indicate that the dorsal motor and ventral sensory area of ventral ganglia, as distinguished by physiologal experiments, is considerably independent of the position of the cell. It may be pointed out that in dorsal lesions it is the connection of the dendrites of motor cells with fibers bearing stimuli to them from other parts of the nervous system that is broken; while in ventral lesions it may be the terminations of sensory fibers or of association cells and their fibers or both that are destroyed. From this it may be seen how indefinite are apt to be results obtained by the physiological vivisection methods. Should experiments be repeated with a thorough knowledge of the location of the cells about a ganglion so as to render it possible to rupture individual cells and not fibrillar connections, and sufficient time is allowed to elapse for the degeneration of the dendrites and neurite of the ruptured cell, it will doubtless be found that ventral and lateral portions of the ganglion are motor.

Such careful experiments are needed and, performed upon the ventro-cerebron, they may, by the aid of either the methylin blue intra-vitam or the bichromate of silver method, be able to demonstrate which of the large number of cells located there perform the function of co-ordinating the movements of the body.

The association fibers of this ventral region of the brain are numerous, and of the many fragments of them seen one of the best is shown in fig. 24. This, as is evident from the figure, occupies the upper portion of the commissural region and sends the greater part of its branches and branchlets dorsally into the lateral region of the proto-cerebron in the dorso-ventral plane of the anterior root of the mushroom bodies. One branch passes forward inside the inner antenno-cerebral tract.

Numerous fibers may be found connecting the antennal morula through its neck of fibrillar substance with the commissure. A single fragment shown in plate XX (fiber 37) sends a process upward in the posterior region that branches below the level of the ocellar glomerulæ, while another is sent forward apparently to the antennal lobe. Just before reaching this it sends a secondary branch downward into the ventro-cerebron. The fibers seen entering the ventro-cerebron from the ventral cord are in some cases remarkable for their size. These large fibers occupy the dorsal region and have already been spoken of in connection with the nerves of the ocelli. Fragments of them have been seen as far back as the first thoracic ganglion, and anteriorly, as before noted, they have been traced in bichromate of silver preparations into the proto-cerebron behind the ocellar glomerulæ. Branches are given off in this region that pass among the glomerulæ to the commissural region as shown in the plate. Much shorter ones are given off in the ventro-cerebron. Another large fiber (fiber 38) apparently ends in the ventro-cerebral and commissural region. Lower down in the ventro-cerebron another fiber is shown (fiber 41) that branches among the fibers from the oral nerves and thence apparently passes backward into the ventral cord. A smaller fiber (40) makes the same connections.

In some of my preparations there may be distinguished what may be described as a roll of fine fibers, the individual fibers of which cannot be traced, that passes through the ventro-cerebron and thence upward through each commissure; whence it crosses to the opposite lower side of the dorso-cerebron or over the anterior part of the roof of the œsophageal foramen. I do not know what this can be unless it is a continuation of the ventral column described by Binet (94). Its passage into the dorso-cerebron is directly contradictory of this author's assertion that "il n'existe dans le ganglion sous œsophagien aucun croisement des connectifs qui prennent leur origine dans le cerveau." But Viallanes (87,88) speaks of a fibrillar tract that passes from the cord to the opposite side of the dorso-cerebron. In close connection with this roll individual fibers may be followed from the cord to the same destination.

What is apparently a branch of this roll continues upward towards the central body in the commissure of the same side, or without crossing the median line.

It is this roll of fibers that has already been mentioned in connection with the dorso-ventral tract, with the fibers of which it seems to come into contact. Assuming that, which is doubtless true, it is the continuation of the ventral columns described by Binet (94) and that the root of the crural and the alary nerves terminating in it are sensory, which is also probably true, there is then seen to be a direct sensory tract for external stimuli from all parts of the body to the calices of the mushroom bodies, a fact of no little importance in completing the chain of evidence demonstrating that the cells of these bodies are the ones that enable the animal to adapt itself to the varying conditions of life.

A similar group of fibers may be followed in copper-hæmatoxylin preparations from the ventral cord through the ventro-cerebron to the antennal lobe within the region of the inner terminations of the motor-fibers to the oral and ventral nerves. In such preparations fibers leaving the tract may be readily seen and it is not a connection between the antenno-motor nerves and the ventral cord such as Cuccati (88) seems to imply in his description of the same tract in *Somomya.* Connecting the pair of tracts in the ventro-cerebral region are four transverse bands of fibers. These have been noted several times in bichromate of silver preparations, but the longitudinal tracts to the antennal lobe were found impregnated but once.

The transverse œsophageal commissure seems to have become completely fused with the ventro-cerebron in the bee, and is apparently represented by a few transverse fibers found in the lower floor of the œsophageal foramen.

The Cell Groups.

Having finished the description, incomplete though it be, of the central fibrillar substance of the bee brain, there still remain the groups of cells clothing the mass to be discussed. The location of these, after recognizing the general form of a hexapod nerve cell, is of little physiological importance compared with the extent and connections of their fibers, but morphologically they may have considerable significance.

As before mentioned, the cells of the brain are gathered into masses that completely cover the fibrillar substance in certain regions and fill in the spaces between its lobes. Thus the spaces between the optic lobes, the antennal morula and the central cerebral mass are completely filled by them, as is also the deep furrow between the two lateral proto-cerebral lobes on the posterior side of the brain.

These masses are, with certain exceptions, subdivided into small groups the fibers of which form a bundle in penetrating the central mass. These groups so far as I have been able to distinguish them may be designated by numbers as follows below. The most prominent of the exceptions to the rule of the formation of small bundles are the cells about the calices of the mushroom bodies. These are very similar in appearance to the small cells filling the central portion of the calyx-cups and their general mass is in some places continuous with that filling the latter, their relation to which may be compared to the overflowing contents of a cup. They are found in the space between each pair of calices and in that between the latter and the fibrillar mass below, anteriorly and posteriorly, and grade into the mass of cells between the central mass and the fibrillar masses of the optic lobes. No processes from any of them to the portion of the brain beneath them have been seen in any of my preparations, but in all they seem to be in some way closely related to the calices. In one instance a process was traced into a calyx from a cell in the space between the pair of cups, and this, branching there, exactly resembled the dendrites of the cells inside. Since this was one of the earlier of my discoveries, and since the boundaries of the cup are not always distinct in non-stained, or bichromate of silver preparations, and since at this moment I am unable to verify the matter, there is here a possibility of a mistake. If not, and the cells are of the same order as those inside the cup, their neurites must be looked for as passing inside to the radiating bundles of fibers.

Between the posterior margins of the stalks and immediately below the calices I have several times found larger cells impregnated, whose processes passed in between the stalks and up between the calices. Perhaps these may be the cells giving rise to the fibers of the superior commissure, but the details to be seen are too poor to warrant a conclusion.

THE CELLS OF THE DORSO-CEREBRON.

I. To proceed with the enumeration of the groups of cells, there may first be noted a small group of medium sized cells, situated dorso-antero-laterally beneath the outer calyx, the processes of which pass almost directly backwards to the neighborhood of the inner surface of the outer stalk and form the processes giving rise to the fibers of the antero-superior optic tract.

II. Behind and below these, but in close proximity, is another group of similar appearance, the processes of which form a tract passing into the fibrillar substance towards the median line of the brain.

III. Below the anterior optic tract nearly half way between the inner optic mass and the optic body is a group of moderately large cells, the tract of fibers from which passes under the optic tract and upwards towards the middle superior surface of the anterior root of the mushroom body, above which they seem to branch. In all preparations where seen there is considerable difficulty in distinguishing the fibers of this tract from the outer branches of the tract from the posterior region of the calices to the root.

IV. Immediately outside of and below the optic body is a similar group whose processes pass beneath the optic tract upward and inward, apparently, along the lower surface of the anterior root.

V. Inside of and below the optic body is a group of cells of median size whose fibers pass upward along the outer side of the anterior root.

VI. Below these and above the antennal morula is a group that sends a tract of fibers upwards across the inner side of the root (figs. 24 and 31, fiber 10 of the diagrams).

VII. Outside of these and above the morula are three small groups that send as many tracts of fibers inward to the central body (fiber 30). They pass below the latter structure and, turning upwards in front of the tubercles of the central body, enter the space separating its dorsal and ventral portions. Apparently they form the tract that is figured by Bellonci (82) as connecting the inner antenno-cerebral tract with the superior commissure on the opposite side of the brain, or as forming a chiasma with its companion from the opposite side.

VIII. Near the latter group is another whose processes form the outer antenno-cerebral tract (fig. 24).

IX. Beneath the calices and in the median plane is a group of cells recognizable in fig. 1, the processes of which pass directly downward, and according to Viallanes (88) enter the œsophageal commissure of the brain, thus forming a chiasma. In the wasp (Viallanes 87) and in *Somomya* (Cuccati 88) their relationships seem to be the same as in the bee, in which I find no evidence of crossing.

X. Immediately behind the latter group is another composed of cells of the same large size, the fibers of which pass backward over the central body and connect it with the fibrillar arch (fiber 2).

XI. Considering the posterior region of the brain there may first be noted a small group situated below the outer calyx at a point where the outer antenno-cerebral tract reaches the dorsal surface of the fibrillar substance. Its processes pass downwards into conjunction with the tract and might be taken for its processes of origin were it not for the fact that bichromate of silver preparations show that its cells are situated in the antennal lobe. Where the fibers of this group go to I have not been able to determine.

XII. Behind the stalks of the mushroom bodies is a small group of large cells whose processes pass between the stalks to the anterior root (fiber 7) giving rise to some of the association fibers in that structure.

XIII. Behind the inner stalk there is a group of medium sized cells whose processes pass inward behind the inner antenno-cerebral tract and behind the central body into which each fiber sends several branches (fiber 5).

XIV. Behind the lateral margin of the central body and beneath the fibrillar arch is a companion group whose fibers pass directly forward and turning about in front of the inner anteno-cerebral tract pass behind and send branches into the central body (fiber 6). The two groups thus form a commissure behind this structure. As before mentioned it is possible that their neurites may be the fibers seen leaving the central body and passing into the lower lateral portions of the protocerebron and towards the commissural region (fig. 5).

XV. Above these groups and between the central body and the fibrillar arch and below the latter is a small group whose processes form a bundle (figs. 2, 5, 6, 8) passing just inside of the inner antenno-cerebral tract over the top of the central body to the median anterior mass of fibrillar substance (fiber 49).

XVI. Above these and in front of the arch is a small group of cells, often staining more deeply than those surrounding them, whose processes pass directly downwards outside of the tract just described and appear to enter the inner antenno-cerebral tract (fiber 3),

XVII. Above the ends of the fibrillar arch is a large group of cells of large size whose fibers form a dorso-ventrally flattened band that passes forwards outside of the inner antenno-cerebral tract and above the superior commissure (figs. 2, 7, 8) and bending about the inner stalk distribute themselves in the fibrillar substance above and outside of the anterior root of the mushroom bodies (fiber 23).

XVIII. Below the fibrillar arch and a little below the commissure of the central body is a loose group of cells whose processes in some cases appear to pass into the superior optic commissure. In others they pass across to the fibrillar mass behind the base of the junction of the roots and stalks of the mushroom bodies (fiber 4).

XIX. Behind group XVI and separated from it by the fibrillar arch is one that appears to send its processes downward into the inner antenno-cerebral tract, but probably they are sent into the central body.

XX. Another group below these and the fibrillar arch sends its processes downward and inward apparently under the superior optic commissure, in front of which they bend upwards and apparently pass to the calices along with the fibers of the superior commissure and those of the inner antenno-cerebral tract.

XXI. The cells about the antennal morula are most numerous in the space between it and the rest of the brain, although they cover almost its entire surface, and are perhaps gathered into as many groups as there are inter-glomerular spaces. One group that should have been noted before is situated in the inner superior side of the neck of the morula and sends its fibers upward through the anterior portion of the central mass of fibrillar substance and near the median line. Near the lower surface of the inner calyx they turn outward over the anterior root.

XXII. Three groups that may be considered as one on account of their situation below the neck of the morula have their processes directed upwards toward the neck.

XXIII. In the lateral lower side of the central cerebral mass are several groups. One large one at the posterior lower edge of the inner optic mass sends its processes straight forward into the fibrillar mass forming the anterior lateral angle of the brain below the anterior optic tract.

XXIV. Another group inside the last sends its fibers into the adjacent posterior angle.

XXV. A little above the group just noted is another that sends its fibers in among the terminations of the posterior optic tracts.

THE CELLS OF THE VENTRO-CEREBRON.

Excepting the dorsal surface the whole of the ventro-cerebron is covered with a mass of cells all of which are of considerable size, but largest ventrally. Among them may be distinguished seven principal groups.

XXVI. A ventro-median group between the origin of the maxillary nerves sends a band of fibers directly through the mass above, passing behind a group of commissural fibers among which may be those of the transverse œsophageal commissure to the dorsal surface.

XXVII. A second ventro-median group also occurs between the origins of the labial nerves. Its fibers after reaching the neighborhood of the dorsal surface separate and apparently reach the latter.

XXVIII. Between this group and the origin of the nerve is another of large cells whose processes form a distinct tract passing upward and outward just outside of the ventral column at the level of which it branches, one half continuing upward and forward towards the commissural region, the other turning outward and becoming lost in the surrounding fibrillar substance.

XXIX. A group outside of the last and behind the origin of the labial nerve sends a band of fibers nearly half way through the mass behind the root of the nerve.

XXX. Between the origins of the labial and the maxillary nerves and outside of them on the lower lateral surface is a large group whose fibers forming a well marked band pass inward and then upward near the root of the maxillary nerve and then upward and inward and apparently forward towards the commissural region.

XXXI. Considerably above the last, or on the upper lateral surface and below the origin of the salivary nerve, is a group whose fibers pass directly inwards and join those of the last group near where these turn forwards.

XXXII. Just above the one just described and in front of the plane of the origin of the maxillary nerves is a group that sends a band of fibers upwards into the commissural region.

Conclusion.

From the facts detailed in the preceeding pages it is evident that even though there are more difficulties in the way of obtaining good results than with the vertebrates, a patient application of the bichromate of silver method will throw as much light upon the organization of the hexapod nervous system as it has upon that of the higher animals. By its aid during the past winter the minute structure of the so-called mushroom bodies has been brought to light and several links added that almost complete the chain of evidence demonstrating the function of these peculiar bodies to be that of enabling the insect to intelligently adapt itself to its surroundings. They are shown to be connected at their calices with two pairs of sensory tracts of fibers from the optic lobes, with three from the antennal lobes and with one, that is probably also sensory, from the ventral nervous system. Their roots are shown by fragmentary evidence, sufficient to warrant the conclusion, to be very probably connected with the inner terminals of motor, or possibly of other efferent fibers, but the exact course of the connection and the number of cellular elements composing it remains to be demonstrated.

The central body is plainly shown to be connected with the fibrillar arch, and possibly the ocellar glomerulæ, and probably through these also with the nerves of the ocelli. Further it is connected with the fibrillar mass in front, and with that below it, but it does not appear to be connected with the mushroom bodies unless it be with their roots. It receives its fibers from cells situated above and behind it, and from some above the antennal lobes.

The olfactory glomerulæ so-called, are shown to be formed by the tuft-like terminals of the fibers composing the antennal morulæ, and in these the terminals of the fibers of the antenno-cerebral tracts seem to play the most prominent rôle.

Several tracts of fibers from the optic lobes connect the latter with other parts of the brain than the mushroom bodies, and some of them doubtless form a part of an optic reflex tract with fibers from the ventro-cerebron and the ventral cord.

Such reflex tracts are not evident in connection with the antennal lobes, but the positions of fiber fragments seen indicate the possibility of reflex connections here also.

Some of the fibers from the ocellar nerves terminate in the tubercles of the central body, others in the ocellar glomerulæ. Some also may connect with the fibrillar arch. Some of the large fibers pass downward and become the enormous fibers of the dorsal surface of the ventral cord.

A tract of fibers, probably a continuation of what Binet calls the ventral column of the ventral cord, passes upward through the commissures and comes into connection above the œsophageal foramen with a dorso-ventral tract to the calices of the mushroom bodies.

A tract from the cord that is probably a branch of the ventral column passes forward to the posterior part of the antennal lobes giving off fibers on their branches along the way among the terminations of the fibers passing into the oral and the antenno-motor nerves.

In the ventro-cerebron of the bee there is recognizable but one root to each of the oral nerves. Of these that of the maxillary nerve is most prominently, and that of the mandibular nerve the most meagerly, developed. The roots connect with the ventral column as described by Binet (94) for one of the branches of the double root recognizable in the Coleoptera.

Motor cells have been found in a ventral position in the ventro-cerebron, which does not accord with the distinction, based upon physiological experiments by Faivre (57) and Binet (94) of a dorsal motor and a ventral sensory area for each ganglion of the ventral cord. This is reconciled by pointing out that it is the fibrillar connections that are destroyed in the lesions produced dorsally, and the association cells and fibres and the terminations of sensory fibers in ventral lesions. If experiments be performed destroying individual cells and thus producing a consequent degeneration of their individual fibers, it will probably be found that the ventral surface of a ganglion may be described as a motor area.

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EXPLANATION OF PLATES.

EXPLANATION OF COLORS.

Red. Cells and fibers of the mushroom bodies.

Blue. Sensory fibers from cells outside of the central cerebral mass.

Violet. Tracts connecting the calices of the mushroom bodies with other parts of the nervous system.

Green. The superior dorso-cerebral commissure.

Brown. Motor and other efferent fibers.

Black. Association and miscellaneous fibers and cells.

EXPLANATION OF ABBREVIATIONS.

a. c.—Anterior commissure.
a h.—Anteror roots of the mushroom bodies.
a. i. c.—Antero-inferior dorso-cerebral commissure.
A. L.—Antennal lobe.
a m.—External antenno-motor nerve.
a. m^1.—Internal antenno-motor nerve.
a. s.—Antenno-sensory fibers.
c. b.—Central body.
c. c.—Fibrillar arch.
c. cb.—Commissure of the central body.
clx.—Calices of the mushroom bodies.
d. v.—Dorso-ventral tract.
e. clx.—Calices of the outer mushroom bodies.
F.—Oesophageal foramen.
g. cb.—Tubercles of the central body.
i. clx.—Calices of the inner mushroom bodies.
i. h.—Inner roots of the mushroom bodies.
i. o. c.—Inferior optic commissure.
l.—Labial nerve.
l. cb.—Lower portion of the central body.
l. t. 2g.—The antero-posterior optic tract.
md.—Mandibular nerve.
mx.—Maxillary nerve.
o^1 o^2 and o^3—Antenno-cerebral tracts. o^1 inner, o^2 middle, o^3 outer.
o. b.—Olfactory bodies or glomerulæ.
o. c.—Ocelli, *oc.*^{1} median; *oc.*^{2} right, *oc.*^{3} left.
oc. n.—Posterior group of fibers from the ocelli.
op. b.—Optic body.
p.—Posterior nerve.
p. i. c.—Postero-inferior dorso-cerebral commissure.
p. o. t.—A posterior optic tract.
r. o. g.—Region of the ocellar glomerulæ.
s.—Stomatogastric nerve.
s. n.—Nerve of the salivary glands.
s. o. c.—Superior optic commissure.
s.æ. g.—Ventro-cerebron or subœsophageal ganglion.
t. op. b.—Anterior optic tract (to the optic body).
st.—Stalks of the mushroom bodies.
n. c.—The superior dorso-cerebral commissure.
u. c. b.—Upper portion of the central body.
u. t. 2*g.*—Antero-superior optic tract.
u. t. 3*g.*—Postero-superior optic tract.
v. c.—Ventral column.
z.—Small cells of mushroom body.

PLATE XIV.

Fig. 1. Frontal section several sections in front of the junction of the roots and stalks of the mushroom bodies, showing association fibers in the median region, and the antennal morula. *7.* Tract of fibers from cells behind the stalks to the anterior root of the mushroom bodies ; *tr.*, large trachea piercing the ocellar nerves and the dorsal region of the brain. *s*, Median nerve of the stomatogastric system; *z*, pyramid of small cells of the mushroom body. Prepared by the formol-copper-hæmatoxylin method.

Fig. 2. Frontal section through the stalks and inner roots of the mushroom bodies, embracing the superior and the antero-inferior dorso-cerebral commissures. Same method as fig. 1.

Figs. 3 and 4. Frontal section. The two anterior roots of the mushroom bodies, showing the bands produced by the bushy terminations of the association fibers. By a modified Weigert method.

PLATE XV.

Fig. 5. Frontal section just behind the inner roots of the mushroom bodies, showing the fibers radiating from the central body. By the formol-copper-hæmatoxylin method.

Fig. 6. A frontal section further back, embracing the inferior optic commissure and the middle and the outer antenno-cerebral tracts. Same method.

PLATE XVI.

Horizontal sections, all by the formol-copper-hæmatoxylin method.

Fig. 7. Section cutting off the inner calices of the mushroom bodies and embracing the superior dorso-cerebral commissure and the top of the central body. *c. cb.* commissure of the central body.

Fig. 8. A section at a lower level embracing the top of the fibrillar arch.

Fig. 9. A section embracing the posterior commissure of the central body and passing just through the top of the lower portion of this. The "pillars" of the fibrillar arch appear on either side of the light tract formed by the large fibers of the ocellar nerves.

Fig. 10. A section embracing the two inferior dorso-cerebral and the lower optic commissures, and two of the posterior optic tracts. The salivary nerve appears in the upper right hand corner as a light spot.

PLATE XVII.

Fig. 11. A frontal view of the brain exclusive of the outer portion of the optic lobes as a transparent object, showing the different bodies in dotted black outline and the fiber tracts in colors. For an explanation of the latter see explanation of colors. General outline and the outlines of the calices taken from a camera drawing of a brain mounted *in toto* in balsam. The outlines of the other bodies and the fiber tracts taken from sections prepared by the formol-copper-hæmatoxylin method and reconstructed by the aid of millimeter paper and by the superimposition of camera drawings.

PLATE XVIII.

Fig. 12. A thick horizontal section embracing the region from the base of the inner mushroom bodies to the middle of the optic bodies. Outlines from formol-copper-hæmatoxylin sections as in fig. 11.

PLATE XIX.

Fig. 13. The remainder of the brain below that represented in fig. 12. Outlines from sections as in fig. 12.

PLATE XX.

Fig. 14. The lateral half of the brain viewed in optical sagittal section from the median plane outward. Outlines from thick sections prepared by the Golgi method.

PLATE XXI.

Cells and fibers from camera drawings of bichromate of silver preparations.

Fig. 15. Cells and fibers from the antennal lobe. x 121.

Fig. 16. Fibers from the antennal nerve and an olfactory body. In the section the right hand branch of the upper fiber was found, after the drawing here was made, to end in a small tuft of branches forming a portion of a glomerula. x 121.

Fig. 17. Terminations of an association fiber in the junction of the stalks and roots of the mushroom bodies. x 121.

Fig. 18. Cells and fibers of the mushroom bodies. x 102.

Fig. 19. Cell bodies of the same. x 121.

Fig. 20. An olfactory glomerula formed by the termination of a fiber of one of the antenno-cerebral tracts.

Fig. 21. The terminations of association fibers in the anterior root of the mushroom bodies.

Fig. 22. A fiber passing across the top of one of the anterior roots and branching profusely in the region just inside of it. Some of the branches seem to penetrate the root.

Fig. 23. Fibers terminating in the calices entering about the origin of the stalk.

Fig. 24. A drawing from three superimposed sagittal sections embracing the region from near the median line to the outer side of the anterior root. *g*, cells on the outside of the antennal lobe; above them and obscuring their fibers is a mass that may be composed of several over impregnated cells just above the antennal morula. For the rest see the diagrams in plates XVII to XX.

Fig. 25. Fiber entering an anterior root and apparently fusing with the parallel fibers. See text, p. 161.

Fig. 26. The smaller kind of fibers terminating in the calices. x 102. See text, p. 157.

Fig. 27. The terminations of the same magnified about 586 diameters.

Fig. 28. Association fibers terminating in the anterior roots. This figure should be viewed from the adjacent corner of the plate. See text, p. 160.

PLATE XXII.

Fig. 29. Tracheal terminations in the calyx of the mushroom bodies, x 102. Frontal section.

Fig. 30. Fiber 36 of diagrams. x 121. Sagittal section.

Fig. 31. Fibre 10 of the diagrams. x 102. It originates from a cell situated above the antennal morula. Sagittal section.

Fig. 32. Fibers from an oblique horizontal section. One with arborescent terminations in the central body. Two passing from one inner root to the region above the anterior root of the opposite side. One passing forwards over the central body and branching in the region in front of it.

Fig. 33. A twisted fiber from the region below and behind the optic body. Sagittal section.

Fig. 34. Fiber from a sagittal section. x 121. It passes below an inner root and sends a branch up over the union of the same with the stalks.

Fig. 35. Fiber passing antero-posteriorly below the central body and sending several branches up in front of the latter. x 121.

Fig. 36. A portion of a motor fiber with its cell-body. See text, p. 174.

Fig. 37. Fiber from the antennal region terminating arborescently in the central body. From a frontal section. x 121.

Fig. 38. Fibers of the posterior inferior dorso-cerebral commissure. x 102.

Fig. 39. Fibers apparently belonging to the antenno-motor nerve, and one commissural fiber of the ventro cerebron.

Fig. 40. Three fibers from two consecutive median sagittal sections. All three are seen to send a process each into the central body. A fragment in the lower part of the figure may be a portion of the outer or right hand fiber of the upper part of the figure. x 121.

Fig. 41. A fiber from the base of the central body sending long branches down into the ventro-cerebron and to the anterior portion of the ventral cord. x 121.

Fig. 42. Two fibers terminating in a so-called ocellar ganglion. x 121.

NOTE.—On page 174, line 8, for "(p.)" read "(p. 161)."

ERRATA.

Page 133, line 5, add 1895-6.
" 184, " 21, for Grylotalpa read Gryllotalpa.
" 192, " 22, delete the copper-.
" 192, " 23, " and A.
" 192, " 26, for Samomya read Somomya.
" 210, delete the note at the foot of the page.

THE ORIGIN AND GROWTH OF BRAIN CELLS IN THE ADULT BODY.

By Howard Ayers.

No part of our anatomical knowledge has had such slow growth as that pertaining to the origin and growth of brain cells and their ultimate relations to one another and to the rest of the body.

The current theory holds that after the nerve cell once sends out its axis cylinder fiber and becomes a functional cell it is incapable of division or further reproduction. For example in the case of the human embryo it is stated that beginning with the fourth week the neuroblasts continue rapid growth up to the third month of fœtal life after which time no increase in numbers takes place. All increase in the brain or its parts after this period is due to the increase in size of the nerve cells (from one to 500 times their original size), the increase in the length and size of the sheaths of Schwann and the medullary matter, the growth of the blood vessels and the neuroglia elements and the connective tissue additions to the brain.

Double Auditory and Electric Ganglion Cells.

In a former publication[1] I figured and described some of the cells of the cochlear ganglion as multipolar and in some cases even as double cells. These latter cells were found to be composed of two nucleated cell bodies closely connected by a short connecting bar of protoplasm, in appearance like the peripheral and central fibers given off from the other ends of these two cells (*cf. loc. cit.*, Pl. I, fig. 6, *x*). The origin of these double cells I was unable to trace at that time but their occurrence in the ganglion was of interest to me in connection with the explanation of the origin and relations of the hair cells. In my recent

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[1] The Auditory or Hair Cells of the Ear and their Relations to the Auditory Nerve. *Journ. Morph.*, Vol. VIII, No. 3, 1893.

studies in the anatomy of the Torpedo brain similar double cells have again come under observation and it is the significance of these cells in the solution of the problems of brain growth and especially the histogenetic processes which are involved to which I wish to invite special attention. I have been able to determine that these double cells in the Torpedo brain may by their complete separation from one another become the ordinary ganglion cells of the brain. In the figures which I shall publish soon, some of the cells are reproduced with great care. All the figures are camera drawings, and are taken from sections of the brain of an adult *Torpedo occidentalis*, the sections being stained by Weigert's method. No single case of the karyokinetic process (in the nucleus) has been found in my preparations but the other relations and conditions of the cells leave no doubt that here in the Torpedo brain functional cells actually divide in the manner so well known for ordinary tissue cells. The stages of cell division which occur in the electric lobes are as follows:

(1). Large motor cells, not to be distinguished from the ordinary functional cells except by the size of the nucleus and cell body.

(2). Cells of the same size as (1) but with two nuclear bodies. Both may be close together in the centre of the cell or widely separated and lying near the periphery of the cell.

(3). Cells showing an evident constriction of the protoplasmic body between the nuclei as though about to divide.

(4). Double cells with short connecting bars which are usually large and band-shaped.

(5). Double cells in which the connecting bar is drawn out into a thin filament, tapering conically from either cell body towards the other.

(6). Since each nerve cell of the brain and ganglia has a peri-lymphatic capsule surrounding it, when the cell body is cut into two the peri-lymphatic space is not at once doubled but the two cells still lie in a common cavity. Because of this it is possible to trace the genetic relation of these electro-motor cells even after they have completely separated by the breaking of the connecting bands, as in those cases where the nerve cells become completely separated. Ultimately of course the lymphatic spaces divide also by completing the capsular wall close about each cell.

The Division of the Cell.

Incisions of two very different kinds are found in the bodies of the electro-motor cells. Those produced by cell fission and those produced by unequal growth in response to local pressure upon some part of the cell by blood-vessels or nerve fibers from some neighboring cell.

Relation to Blood-vessels.

The large ganglion cells of the Torpedo brain have apparently approached the limit of the size of nerve cells, which require, as we know, specially good facilities for nutrition (respiration and excretion included). The usual vertebrate brain is made up of cells varying in size from .002 m.m. to .1 m.m. and they are disposed about the courses of the blood-vessels in such a way as to admit of easy transfer of food to the cells and of the nitrogenous waste products away from the cells.

In the Torpedo's electric lobes, however, there is added to the usual arrangements a special feature in the relation of the cells to the blood-vessels. It consists in the migration of the over-grown ganglion cells to the walls of the arterial capillaries on the surfaces of which they spread themselves out and more or less completely surround the vascular tubes so as to present the appearance of being more or less deeply grooved or even perforated. The cell wall in immediate contact with the capillary cells is very thin and thus the very best facilities are presented for the performance of the physiological activities of the brain cells.

One of the anatomical causes of the increase in size of the electric lobe of the Torpedo is the production of new cells by the division of already functional electro-motor cells. This division occurs most abundantly at the ventricular surface of the lobe.

There is a very evident grouping of the cells in the electric lobes in groups of 2, 3, 4, or larger numbers up to 12 or more. The axis cylinder processes of the members of a group converge towards a common centre, indicating, I think, a common origin from a single cell.

While most cells of the electric lobe possess a single nucleus, the number having two nuclei is relatively large (500 in each lobe). Cells with three nuclei are occasionally found, 50 in each lobe.

The centrosome is plainly visible in some of the cells.

Morphological Laboratory, University of Missouri, Columbia, Mo., March 10, 1896.

THE INNERVATION OF THE AUDITORY EPITHELIUM IN MUSTELUS CANIS, DE KAY,

By A. D. MORRILL.

I wish, at this time, to give a brief preliminary statement of the results obtained by the use of methylen blue in the study of the auditory epithelium of the "smooth dog-fish."

The fibers of the auditory nerve lose their medullary sheath on entering the sensory epithelium of the ampullae and branch at different levels, although the branches are much more numerous at the base of the hair cells. From the latter branches, many of which extend horizontally, numerous extremely fine nerve fibers arise which end either in characteristic enlargements in contact with the proximal portions of the hair-cells or pass between them to end free near the surface in similar but smaller enlargements.

The nerve fiber often branches at the base of the hair-cell, the two portions closely adhering to the cell and ending in enlargements at nearly the same level on opposite sides of the cell. In other cases the fiber can be traced to the cell and may end in a single enlargement at its very base. Occasional free nerve endings were found in the central portions of the auditory epithelium, at a considerable distance from the hair-cells, and end free in enlargements.

Conclusions.

(1) No continuation of the nerve into the cell was observed although the cells were semi-transparent.

(2) No trace of Kaiser's cup-like mass was found at the base of the hair-cells.

(3) The triangular enlargements at the points where the nerves branch are due to the nerve sheath, through which the nerve fibers can be seen.

(4) Satisfactory evidence of anastomosis of nerve fibers was not obtained.

(5) There are two kinds of nerve endings in the auditory epithelium, the one being free near the surface and the other ending in knob-like structures in contact with the base of the hair-cells.

(6) No varicosities were found on the nerve fibers in the best stained preparations, while the terminal enlargement was always present.

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NEURAL TERMS, INTERNATIONAL AND NATIONAL.[1]

By Burt G. Wilder, M. D.,
Professor of Neurology, etc., Cornell University.

Introduction.

Five conditions have led to the preparation of this article at this time.

§1. The American Neurological Association, at its session in Philadelphia, June 5, 1896, unanimously adopted the Report of the Committee on Neuronymy embodying the previous reports of three other American committees and extending the list of Latin terms recommended from eleven to forty; see §80.

§2. The Anatomische Gesellschaft, at its session in Basel, April 19, 1895, adopted the Report of its Committee on Anatomische Nomenclatur, comprising a list of Latin names for all the visible parts of the human body (see Table VII), and provided for its revision at intervals of three years. Presumably the Gesellschaft sanctioned the declarations of principles which had been published by the secretary of the committee (Krause, '91, '94; see Part V.)[2] The list was published early in the summer of 1895 as a part of an article, "Die Anatomische Nomenclatur," by Professor Wilhelm His, constituting a "Supplement-Band" to the "Anatomische Abtheilung" of the *Archiv für Anatomie und Physiologie.* Certain principles and certain portions of the list merit high commendation; others,

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[1] The more important parts of this article were embodied in a lecture, "The Present Aspects of the Nomenclature of the Brain," delivered at the Marine Biological Laboratory, Aug. 3, 1896.

[2] See the Bibliography, Part IX. The date after the name of a writer designates the year of publication. The joint works of S. H. Gage and myself are indicated by W. & G., '82, '86, '89.

in my opinion, are to be as deeply regretted. Among the least acceptable features are the designations and coordination of the encephalic segments and the assignment of parts thereto; Table VI.

§3. In the official action of the Gesellschaft (Part V), and in a recent manual by the president of its committee, Professor Albert von Kölliker are declarations against the efforts of the American committees which may be due in part to ignorance or misapprehension of the facts. As chairman of two of the American committees and as secretary of a third, I may not inappropriately endeavor to remove the impediments to a clearer comprehension of our position. I particularly desire to free the committees, their individual members, and the associations which they represent, from responsibilities not yet assumed by them.

§4. In the article above mentioned Professor His not only evinces a failure to comprehend the aims of the American committees, but also misrepresents what has been done by me as an individual. Such misrepresentations, unless corrected, might well, especially in Germany, impair the efficiency of my past and present utterances upon Anatomic Nomenclature. A correspondence begun in December, 1895, has failed to adjust our disagreement, and it is most reluctantly submitted to other anatomists. In an experience of thirty-five years this is my first scientific controversy, and I trust it may be the last.

§5. During the quarter of a century since my attention was first drawn to the defects of current anatomic terms my convictions may be assigned to five different stages dating respectively from 1871, 1880, 1884, 1889 and 1895. Beyond the last I now discern no opportunity for progress excepting in the elaboration of details. It is my desire to devote the rest of my life to the study of the brain, and this seems to be a fitting time for submitting such statements of principle and suggestions of practice as may facilitate the labors of others upon Anatomic Nomenclature.

§6. This article comprises nine parts as follows:

I. Definitions of certain terms employed in the discussion of Anatomic Nomenclature.

II. Stages of the writer's terminologic progress.

III. Report of the Committee on Neuronymy of the American Neurological Association, with commentaries.

IV. Discussion of the differences between certain terms in that report and those adopted by the Anatomische Gesellschaft.

V. Reply to criticisms offered by the Anatomische Gesellschaft and by its members.

VI. Correspondence with Professor Wilhelm His.

VII. List of the Neural terms adopted by the Anatomische Gesellschaft and of those now preferred by the writer.

VIII. Concluding remarks.

IX. Bibliography.

Part I. Definitions.

§7. It is assumed that all who read this article seriously are familiar with the parts of the brain referred to, and that they have likewise a "working knowledge" of ancient and modern languages. But space will be saved by the employment of certain terms which are rather linguistic than anatomic, and some of which either are comparatively new, or are here used in new or restricted senses; these are therefore first briefly defined. The definitions of course apply to the Latin forms of the English words; the adjectives and other derivatives are self-explanatory.[1]

§8. *Onym.*—From ὄνυμα, same as ὄνομα, a name. Proposed by Coues ('82) in the sense of biologic name. It is seldom needed alone but is the essential element or base (§30) of many derivatives.

§9. *Toponym.*—From *onym* and τόπος, place. A term indicating location or direction; e. g. *lateral*, at the side; *laterad*, toward the side; *transection*, cutting across.

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[1] Definitions may be found also in the more recent English and medical dictionaries. Some of the terms are discussed in my articles, '85 and '89.

§10. *Organonym.*—The name of a part or organ; e. g. *humerus.*

§11. *Neuronym.*—The name of a part of the nervous system.

§12. *Polyonym.*—A name consisting of more than one word; e. g. *fissura centralis; rostrum corporis callosi; plexus chorioidea ventriculi quarti; iter a tertio ad quartum ventriculum.* This use of the word *polyonym* is analogous to that of *polyandry, polygamy,* etc.; see note to p. 518 of W. & G., '89.

§13. *Dionym.*—A term consisting of two words; e. g. *vertebra thoracalis; arteria brachialis; gyrus callosalis.* Dionyms are perhaps the most common kind of polyonyms. They have a certain analogy with the technical names of animals and plants since the noun often indicates a group of similar or related parts and the adjective designates a specific member of the group.

§14. *Trionym.*—A term consisting of three words; e. g. *vertebra thoracalis prima.* Here, as with the so-called trinomials of zoology, the second adjective may be said to designate a subspecies.

§15. *Mononym.*—A name consisting of a single word; e. g. *insula.* Strictly speaking a mononym is either a noun or some other word used as a noun. But the application may be conveniently extended as in the next definition.

§16. *Mononymic Qualifier.*—A qualifying word, (adjective, participle or genitive), consisting of a single word; e. g. the second word in each of the following dionyms: *Gyrus postcentralis* (for *G. centralis posterior*); *G. subfrontalis* (for *G. frontalis inferior*).

§17. *Ordinal Names.*—These indicate the order or numeric location of a member of a series; e. g. *costa prima; vertebra thoracalis prima.*[1]

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[1] With any series extending lengthwise of the vertebrate body the member nearest the head is regarded as first. The only instance known to me of disregard of this conventional assignment is the enumeration of the segments of the brain in the schema of Prof. His as adopted by the German Committee.

§18. *Attributive Names.*—These refer, at least in part, to some real or fancied attribute; e. g. *callosum; oblongata; vagus.*

§19. *Simile Names.*—These express real or fancied resemblances to other objects by means of the suffixes *formis* or *oides*; e. g. *restiformis, trapezoides.* Most simile names might as well be converted into the corresponding metaphoric names; e. g. *restis, trapezium.*

§20. *Metaphoric Names.*—The names of non-anatomic objects are transferred to parts having some real or fancied resemblance thereto; e. g. *pons, insula, thalamus, falx.*

§21. *Metaphoric Diminutives.*—Since many parts are smaller than the more familiar objects whose names have been transferred to them the diminutive form is sometimes used; e. g. *vallicula* (from *vallis*); *fasciculus* (from *fascis*); *colliculus* (from *collis*); *clavicula* (from *clavis*). Since, however, size is so variable and unessential an attribute, and since verbal diminutives are commonly longer than their originals, the latter might as well be employed. But this suggestion would not apply to a case where there are two of a general sort differing mainly in size; e. g. *cerebrum* and *cerebellum; falx* (*falx cerebri*)*; falcula* (*falx cerebelli*).

§22. *Polychrestic Word.*—One that does duty in many connections; e. g., *occipitalis,* which in various combinations aids in designating at least twenty-five different parts.

§23. *Homonym.*—A name applied to two or more different parts; an ambiguous term. An extreme case is that of *os* as signifying either a bone or an orifice; the oblique cases and derivatives of course distinguish them. *Medulla* has been applied to several parts. *Epiphysis* may designate the end of a bone or a part of the brain. Theoretically objectionable, the context commonly frees homonyms from serious ambiguity.

§24. *Idionym.*—A word which, at least in anatomy, refers to but one part; e. g., *cerebellum; thalamus; chiasma; pons; insula.*

§25. *Idionyms by Recombination. Cornu posterius,* as employed by most anatomists, is a homonym, designating either a cavity of the cerebrum or a feature of the myel (spinal cord). But *postcornu*, as introduced by me in 1881, applies only to the cerebral cavity and is thus an idionym.

§26. *Contextual Explicitness.*—For want of a better phrase this may refer to the possibility of employing terms that might be ambiguous but for their association with others. A common example is *cord*, which may be used in at least five senses, by the neurologist, the laryngologist, the surgeon, the obstetrician and the embryologist. When an entire publication or section of it refers to a group of organs of the same general character, then the generic element of their polyonymic designations may be often omitted and the specific alone employed; *e. g.*, with arteries, fissures, gyres, *etc.* Indeed, to be absolutely explicit or idionymic in all cases would require many new names or the addition of genitives or other qualifiers to many already existing.

§27. *Locative Names.*—The location of a part is a general and comprehensive attribute and, as remarked by Owen, "signifies its totality without calling prominently to mind any one particular quality, which is thereby apt to be deemed, undeservedly, more essential than the rest."

§28. *Prepositional Locatives.*—With these the qualifying prefix, a preposition or adverb, indicates the location of a part relatively to some other part, more important, more easily recognized, or earlier designated. *Praecuneus* designates a cortical area just "in front of" the cuneus.

§29. *Adjectival Locatives.*—These indicate either the location of a part within some general region, or its membership of a series. *Vertebra thoracalis* designates a spinal segment in the thorax. *Commissura anterior*, *cm. media*, and *cm. posterior* distinguish members of a conventional series. *Mesencephalon*, *prosencephalon* and *metencephalon* designate members of a natural series, and the prepositions have the force of adjectives; see §§173-192.

§30. *Base* (*verbum basale*).—The original or more essential element of a derivative, as distinguished from prefixes, suffixes, inflective terminations, etc.

§31. *Derivative.*—A word derived or formed either immediately or remotely from another; e. g., *inorganic*, *organize*, and *organs* are derivatives of *organ*.

§32. *Correlative Names.*—These are derivatives containing no obvious locative element but intended to indicate some relation between the part so designated and the part designated by the base; e. g., *fissura calcarina* associates an ectal fissure with the calcar, an ental ridge.

§33. *Eponyms.*—Personal names, i. e., derived from the names of individuals; e. g., *fissura Sylvii; pons Varolii.* Some objections to these are stated in W. & G., '89, §59,[1] and as they are condemned by the German committee most of them will probable disappear. An exception perhaps should be *fissura Sylvii* (see §120).

§34. *Pecilonymy.*[2]—Proposed by me (W. & G., '89, §16) as a mononym for *terminologic variety* or *inconsistency* within a single article or work; e. g., the use of *fissura* and *sulcus* for the same cerebral furrow, of *centralis* and *Rolando* for the same fissure. Between pp. 464 and 507 of Schwalbe's "Neurologie" occur *Crus fornicis* (498), *Fornix-schenkel* (464), *Fornix-säulchen* (507), *Gewölbe-schenkel* (464). His ('95) adopts *Foramen interventriculare* but uses *Foramen Monroi* on p. 166 and "*Monro'schen Loche*" on p. 167.

§35. *Direct Pecilonymy.*—In the cases mentioned above and others that might be adduced from nearly every work known to me, one and the same part is designated by two or more substantives or words used substantively. This is *direct pecilonymy.* A special variety of it occurs when different generic names are applied to two homologous parts; e. g., in Huxley and Hawkins' "Comparative Osteology" the arm is called the "anterior *extremity*" the leg, the "hind *limb.*"

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[1] There may be added the liability of misspelling; *Monro* has been spelled Monroe, Munro and Munroe; see my paper, '80, *d*.

[2] From ποικίλος, various, changeful, inconstant; compare ποικῖλόβουλος, of changeful counsel; *pecilopoda*, various footed. The unfamiliar term is perhaps the less objectionable in that it stands for a habit which may ere long be eradicated.

§36. *Indirect Pecilonymy.*—But when a certain substantive is used in one passage, and in another an adjective or other derivative from a different substantive, the pecilonymy is indirect or implied; *e. g.*, "certain fibers are called *peduncular* because they pass into the *crura* cerebri." Very commonly a certain fissure is named *Rolando*, but adjoining gyres, *paracentral*, *anterior central*, etc.

§37. *Pecilonymy by Permutation.*—When a name, or the adjective part of a name, contains two or more elements of approximately equal value, they are subject to accidental or intentional transpositions that may cause misapprehension. For example in his paper on the brain of *Ateles* (*Zool. Soc. Proc.*, 1861) Huxley refers to the same fissure as occipito-temporal on p. 258 and as temporo-occipital on p. 260. One might infer that two different things were indicated just as, in chemistry, *hydro-carbon* and *carbo-hydrate* have different significations. Similar diversity of usage exists with regard to the occipital fissure, which is called by some *occipito-parietal* and by others *parieto-occipital.* *Orbito-frontal* and *fronto-orbital* constitute another instance.

§38. *Abbreviational Pecilonymy.*—The following is a good example of a bad system: in the translations of two of Meynert's works occur *corpus quadrigeminum; corp. quadrigeminum; corp. quadrigem.; corp. quadrig.; corp. quad.*

§39. *The Perpetration or Toleration of Pecilonymy* may be ascribed to five mental conditions:

A. Pure heedlessness.

B. Indifference to the just claims of readers and especially of students.

C. Pride in the hardly gained familiarity with the synonymy of parts.

D. Desire to avoid repetition, as in certain forms of literary expresssion; see W. & G., '89, §73, B, note.

E. Unwillingness to commit oneself to a particular[1] name.

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[1] In some cases all the current titles of a part are so unacceptable that one recalls Shakespeare's epigram as to the "Small choice among rotten apples," and the demand of the dissatisfied guest, "If this is tea, bring me coffee; if it is coffee, bring me tea."

Such hesitation constitutes the only valid justification of pecilonymy. But the same end might be gained by a simple declaration, without the risk of confusing or misleading the reader.

§40. *Magnilogy.*—The employment of lengthy or ponderous terms when briefer would suffice. This is simply one form of what may be called *anatomic esotery.* Now that the choice is offered, the anatomist who deliberately says *aponeurosis* for *fascia*, *anfractuosity* for *fissure*, and *convolution* for *gyre*, thereby arrays himself with the village orator in whose turgid discourse a fire is always a conflagration.

§41. *Perissology.*—The following example of needless amplification occurs in a special article by a distinguished neurologist in a leading metropolitan medical journal: "The anterior column of gray matter extends throughout the spinal cord, and the upper enlarged intra-cranial end of the spinal cord, which is known as the oblong cord or medulla (medulla oblongata)." As shown in W. & G., '89, 529, §76, the information contained in these thirty-two words might have been given in fifteen.

§42. *Equivalents, Synoyms, and Isonyms.*—Equivalents are terms meaning the same thing, e. g., *pons*, *pons Varolii*, *pont*, and *Brücke.* Strictly speaking, *pons Varolii* is a synonym, or equivalent in the same language, while *pont* and *Brücke* are isonyms or equivalents in other languages. But for simplicity all may be here regarded as synonyms, just as, in biology, *synonymy* embraces all the appellations of organisms, whatever their nationality. Hence one may recognize two groups of synonyms, viz., *paronyms* and *heteronyms.*

§43. *Paronyms and Heteronyms.*—Excluding *pons Varolii* (the dionymic, eponymic synonym of *pons*), the other equivalents are the French *pont*, the Italian *ponte*, the Spanish *puente*, the German *Brücke*, and the English *bridge.* Of these, the first three are obviously related to the Latin *pons*, while the last two have no such relationship. The former have been called by me paronyms,[1] the latter, heteronyms; '85, c, 9; W. & G., '86,

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[1] *Paronymy* or paronymization includes what has been called word-adoption, word-appropriation, word-assumption, word-borrowing, etc.

preface; W. & G., '89, 519. A familiar illustration is the Latin *canalis,* of which *canal* is the English paronym, while heteronyms are *tube, passage, trough* and *water-course.* The Greek ὄργανον might be rendered by *part, instrument* or *agent,* and these are its English heteronyms; but the Latin paronym is *organum;* the French, *organe;* the Italian, *organo;* the English, *organ;* and the German, *Organ.* Each of these is, so to speak, a geographic variety of the original or antecedent word; indeed it may be regarded as the same word modified in accordance with the genius of each language. The case may be compared with that of a traveller who maintains his essential identity notwithstanding "in Rome he does as the Romans do," and in other countries conforms to the customs of the inhabitants in respect to garb and demeanor.

§44. *Methods of Paronymization.*—For linguistic reasons paronymy is general and easy with the Romance languages, less so with the Germanic and with English. Still there are examples enough (Tables II, IV) to warrant the belief that into either may be adopted any Latin substantive or adjective.[1] Paronymic methods vary with the language and with the word. Some of the modes of conversion of Latin words into their Anglo-paronyms are formulated in W. & G., '89, §66. The instances there given involve more or less orthographic modification, ranging in extent from the case of *fiber* (from *fibra*) to that of *alms* (from *eleemosyna.*) These are *changed paronyms.*

§45. *Unchanged Paronyms.*—But there are other evidences of paronymization, *viz.,* (a) Pronunciation, e. g., *Paris, Detroit.* (b) Hyphenation with a word unmistakably of another language; e. g. in *Balken-splenium,* the hyphen indicates the adoption of the Latin *splenium* as a German word. (c) Combination, e. g., *Ponsfasern* and other cases in Table IV. (d) Declaration that the writer regards the unmodified word as adopted.[2] (e)

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[1] Also other and perhaps all parts of speech, but they do not concern us here.

[2] Were all foreign words italicized, then in a given case the non-italicization of a word would indicate its adoption. Since the Germans commonly capitalize all nouns, that feature does not not necessarily signify that a word is regarded as an unchanged paronym; see Table.

Employment of the vernacular form of the plural or of an oblique case; e. g., the Latin plural of *lens* is *lentes*, but the English is *lenses*; so *atlas* (*atlantes*) *atlases; enema* (*enemata*) *enemas; animal* (*animalia*) *animals:* in the phrase "fibers of the callosum," the last word might still be regarded as Latin; but if one said "callosum's fibers" the English possessive would indicate paronymization.

§46. *International and National Terms.*—By general consent Latin constitutes a common or international language for scientists. National terms may be either unrelated to the Latin antecedents,[1] hence heteronyms; or obviously related thereto, hence paronyms. *Sea-horse, Cheval marin* and *Seepferd* are synonyms (in the broader sense, §42) but to either an Englishman, a Frenchman or a German, two of them are foreign words and unacceptable. *Hippocampus* is distinctly a Latin word, and the frequent occurrence of such imparts a pedantic character to either discourse or printed page. *Hippocamp, hippocampe, hippocampo* and *Hippokamp* are as distinctly national forms of the common international antecedent (not to invoke the original Greek (ἱππόκαμπος), and are readily recognized by all, while yet conforming to the "genius" of each language.

§47. *The Paronymic Advantages of Mononyms.*—The object of paronymy is to endow anatomic language with nationality without obscuring its internationality. With mononyms the paronymic changes (if any) are slight, involving mostly the termination, or, with German, the capitalization of nouns and the occasional replacement of *c* by *k*. The word is readily recognized, and its abbreviation would be the same in any language. But with polyonyms the relative position of the substantive and the qualifier is commonly reversed in the two groups of languages, Romaniform and Germaniform. In the former the noun more often precedes, in the latter it almost always follows.[2] Hence there is a different aspect of the entire term, and the

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[1] Or related so remotely that the connection is obscure.

[2] Notwithstanding the familiar exceptions, *alma mater, pia mater,* and *notary public.*

abbreviations are transposed. The Anglo-paronym of *commissura posterior* is *posterior commissure*, and the respective abbreviations might be *c, p.* and *p, c.*; but if the Latin dionym be mononymized into *postcommissura*, the English paronym is *postcommissure*, and the abbreviation *pc.* answers for both. See §§61-64.

§48. *Limitations to Paronymy.*—As already admitted with regard to mononymy (§88), the "nature of things" forbids the rigid and universal application of the principle of paronymy. Certain parts, so exposed or so vital as to have gained early and popular attention, have received vernacular names or heteronyms which are brief and generally understood. Such are *head, hand, foot, heart* and *brain.* Indeed the use of the Latin equivalent for either of these would impress most persons as pedantic. But this concession of, for example, the sufficiency of *brain* instead of *encephalon* does not warrant the retention or formation of an indefinite number of inflectives, derivatives and compounds from the heteronym. The same remark applies to other languages.[1]

Part II. Stages of the Writer's Terminologic Progress.

§49. The following summary of the changes of my views during a quarter of a century shows, I trust, a general advance in the comprehension of the subject and justifies me in commenting upon the labors of others.

§50. I. 1871-79. In an effort to confirm, extend and modify certain morphologic ideas of my teacher, Jeffries Wyman, I enumerated ('71, 172) the following requirements of technical terms: 1. Classic Derivation. 2. Capacity for Inflection. 3. Brevity. 4. Independence of Context for Signification. 5. Non-ambiguity to the Ear as well as to the Eye. 6. Previous Use in a Kindred Sense.

Of the thirty-three names then adopted or proposed for

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[1] Of the two German vernacles for encephalon, *Gehirn* is more commonly used alone and *Hirn* in composition. On my list there are 35 compounds of Gehirn and 106 of Hirn; moreover, of the former, one-half are duplicated among the latter.

the limbs, their segments and joints[1] all were mononyms (§ 15). With most were given the singular and plural nominative and genitive. Two, *omozone* and *ischizone*, were Anglicized (paronymized). The designation of the fingers by the adjectives, *index*, *medius*, *annularis* and *minimus*, without preposing the substantive *digitus*, recognized Contextual Explicitness (§ 26) and the validity of adjectival nouns (§ 117).

§51. Then, as now, the most desirable (yet not absolutely essential [§§ 67-70]) attributes of technical terms seemed to me (1) Classic Derivation, (2) Capacity of Inflection. But both these had been adumbrated long before by Barclay ('03) and Whewell ('40), and distinctly enunciated by Owen ('46, 171) in the immortal paragraph wherein *myelon* was proposed:

"The fore part of the neural axis * * is called the brain or encephalon; the rest I term *myelon*, (Greek μυελός marrow). As an apology for proposing a name, capable of being inflected adjectively, for a most important part [see W. & G., '89, § 48] of the body which has hitherto received none, I may observe that, so long as the brief definitions, 'marrow of the spine,' 'chord of the spine,' are substituted for a proper name, all propositions respecting it must continue to be periphrastic, e. g., 'diseases of the spinal marrow,' 'functions of the spinal chord,' instead of myelonal [myelic][2] diseases, myelonal functions; or if the pathologist speaks of 'spinal disease,' meaning disease of the spinal marrow, he is liable to be misunderstood as referring to the disease of the spinal or vertebral column. But were the anatomist to speak of the canal in the spinal marrow of fishes as the 'myelonal canal' he would at once distinguish it from the canal of the spinal column. The generally accepted term

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[1] Among the few new terms were *omos*, for shoulder-joint, and *omozona* and *ischizona*, for shoulder-girdle and pelvic-girdle respectively. They still seem to me preferable to the "*Articulatio humeri*," "*Cingulum extremitatis superioris*" and "*Cingulum extremitatis inferioris*" of the German list.

[2] On several previous occasions ('85, 354; '85, 12; '89, 531) I have shown that analogy with words like *angel* and *angelic* (from ἄγγελος) calls for *myel* and *myelic* as the English nominative and adjective of *myelon*; *myelonal* is clumsy, and analogy would involve the replacement of *encephalic* by *encephalonal*.

'chorda' or 'chorda dorsalis,' for the embryonic gelatinous basis of the spine, adds another source of confusion likely to arise from the use of the term 'spinal chord,' applied to the myelon, or albuminous contents of the spinal canal."[1]

§52. In 1873 ('73, 306) Owen's examples of *ectogluteus, mesogluteus* and *entogluteus* led me to propose the locative mononyms *ectopectoralis* and *entopectoralis* for the two frequently named muscles whose relative proportions in most mammals are so misrepresented by the adjectives *major* and *minor.*

§53. I have already ('85, *c*, 5 '90, *g*, 1) expressed my sense of obligation to Owen's terminologic precepts and examples, and my regret that the limits of the article, "Anatomical Terminology" (W. & G., '89) did not permit even more extended selections than are embraced among the "Aphorisms respecting Nomenclature" therein.

§54. II. 1880-1883. While preparing a paper on the brain of the cat ('81, *d*) and (with S. H. Gage) a volume of directions for laboratory work (W. & G., '82) I adopted from Barclay ('03) the unambiguous toponyms (§9) *dorsal, dorsad,* etc.; replaced his *mesion* by *meson,* the direct paronym of *μέσον*; added *ectal, ental,* etc.; and simplified some organonyms, especially muscular (W. & G., '82, 207) and neural ('80, *f;* '81, *b, d*) in the following ways: (a) Dropping unessential adjectives (*opticus* from *thalamus* and *chiasma*); eponymic (§33) qualifiers (*Varolii, Reilii, Rolando*); and generic nouns (*corpus, mater,* and *membrana*) from adjectives which were sufficiently distinctive and could be used as substantives (*callosum, dura, mucosa*); (b) substituting prepositions for adjectives (e. g., *postcommissura* for *commissura posterior*); (c) Replacing certain polyonyms by mononyms more or less nearly akin thereto (e. g., *lamina terminalis* by *terma*); and (d) Abandoning the anthropotomic misnomers of the encephalic cavities in favor of mononyms co-

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[1] The foregoing first appeared half a century ago; the mononym *myelon* was employed consistently by Owen, and on at least one occasion by his rival, Huxley ('72, 65). These facts should secure for it the consideration due to high authority and moderate antiquity, and forestall any hasty proposition to employ it in a different sense.

ordinated with the commonly accepted titles of the encephalic segments (e. g., *Aquaeductus Sylvii* and *Iter a tertio ad quartum ventriculum* for *mesocoelia*)[1]

§55. In respect to terminologic practice, before the publication of any paper or book there was made a list of the Latin terms to be employed, with abbreviations thereof, and these were adhered to throughout.

§56. Notwithstanding their defects, these efforts to improve anatomic language elicited favorable comment, helpful criticism, and more or less actual adoption from Oliver Wendell Holmes ('81), Joseph Leidy ('85, '89),[2] Henry F. Osborn ('83, '84), E. C. Spitzka ('81) and R. Ramsay Wright ('85).

§57. III. 1884-1888. Although now satisfied as to the correctness of the general system and as to the excellence of most of the individual terms, I began to realize more fully the magnitude and difficulty of the task and the necessity for counsel and coöperation. In the summer of 1884, at my suggestion, committees were appointed by the American Neurological Association and the American Association for the Advancement of Science. The constitution of these committees (§ 80) insured that no hasty action would be taken, and warranted the hope that any conclusions reached by them would be considered seriously here and abroad. Personal conferences were held when practicable, but most of the work of comparing views and preparing preliminary reports was done by correspondence.

§58. As collaborator on a medical dictionary (Foster, '88-'94), I undertook to obtain a list of names already applied to parts of the central nervous system. In 1888 the total was 10500, distributed as follows, in round numbers: Latin, 3100;

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[1] Nothing in my terminologic experience has been more gratifying and encouraging than the approximate coincidence of a similar proposition by T. Jeffery Parker ('82, '84.)

[2] While engaged upon the new edition of his "Anatomy," Professor Leidy wrote to me under date of Jan. 20, 1885: "I wish to aid in reforming the nomenclature of Anatomy, and in doing so propose to Anglicize the names to some extent (§46). Will you please look over this list of muscles and tell me whether I can do better with any of the names." Ten days later he submitted a list of the many terms. Many of my suggestions were adopted.

English, 1800; French, 1800; Italian and Spanish, 900; German, 2900. Assuming the number of parts or features to be 500-600, there were evidently many superfluous neuronyms, especially in Latin and German. The excess in these two languages might be accounted for in part by the international character of the former, and by the large number of publications in the latter.

§59. But a careful scrutiny disclosed two other causes: (1) Many of the Latin names, especially the older, comprised so many words as to constitute descriptive phrases, and to furnish opportunity for conscious or unconscious abridgement and permutation (§ 37); each resultant combination had to be regarded as a name. In W. & G., '89 §56, are enumerated no less than twenty-three distinct Latin names for the fibrous bundle connecting the cerebellum with the oblongata; they average nearly 2.7 words each.[1]

§60. Of the German names a small proportion (58, or two per cent. of the total) had any obvious resemblance to equivalent Latin terms (*Fissur* to *fissura*, *Commissur* to *Commissura*, *Centralcanal* to *Canalis centralis*); the vast majority were vernacular translations (e. g., *Brücke*, *Schenkel*, *Seepferdefuss*, *Sehhügelpolster*).[2] Different writers made different translations, and considerable variation occurred in different parts of the same publication (§ 34). Hence there arose a multitude of terms, acceptable and intelligible only to readers of the same nationality, and bearing no relation to the original or international Latin terms. In a greater or less degree the same might be said of the other modern languages.

§61. It will be seen that two opposing influences were operating. Each anatomist preferred to employ terms belonging to his own language; at the same time he preferred that other anatomists should employ Latin terms with which he was

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[1] All these might be replaced by the single word, *postpedunculus*.

[2] Without imputing even so worthy a motive as national self-satisfaction, the effect was as if certain neurologists had yielded to a desire to confer upon the printed page an obtrusively German aspect.

already familiar, or which were intelligible without an intimate acquaintance with other modern languages than his own.

§62. With a view to reconcile these two opposing tendencies I formulated ('85, *c*) the distinction between heteronyms (§ 43) and paronyms (§ 44),[1] and proposed that, with few exceptions (§ 48) heteronyms should be discarded in favor of paronyms. "Since each paronym suggests the original Latin name, the latter forms a bond of intelligence between writers and readers of different nationalities."

§63. The international advantages of paronyms over heteronyms have been distinctly recognized, and the principle indorsed, by the American branch of the International Committee of Biological Nomenclature, and by the American Association for the Advancement of Science (Proceedings, 1892, 233).

§64. That mononyms are more readily and uniformly paronymized than polyonyms, and dionyms than other polyonyms, has been already mentioned (§ 47) and is indeed self-evident.

§65. IV. 1889-1894. But the recognition of the nature and causes of neuronymic hypertrophy and deformity, and even the formulation of general principles of relief, still left unaccomplished the necessary operations of excision and correction. My inability to decide in season which should be regarded as *the* names, and which as merely synonyms, was one of the reasons for not accepting the invitation of Dr. Foster to frame the definitions in the dictionary above mentioned. Partial lists had been prepared in connection with the "Anatomical Technology" (W. & G., '82, 436-438) and the "Cartwright Lectures" ('84, *a*). The latter list ('84, *b*) contained 115 names exclusive of the fissures and gyres and blood vessels. In connection with a paper, "Owen's Nomenclature of the Brain" ('90, *g*), there was presented to the Association of American Anatomists a "Macroscopic Vocabulary" of about 200 names,

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[1] The history of the process, and the names of my present and former colleagues who so materially assisted me, are given in several publications ('85, *c;* W. & G., '86; '89).

with synonyms and references ('90, *h*). The vessels, fissures and gyres were estimated at 140, and lists of them were published at various periods ('85, *e, f, g;* '86, *g*).

§66. This made a total of about 340 parts or features of the central nervous system the designations of which I had selected or framed from among the vast accumulation of available terms. These names had already been found serviceable in the research and instruction carried on under my direction; and they were embodied in the articles on the gross anatomy of the brain ('89, *a, b, c;* '93, *a, b, c*); and questions involved in their adoption were discussed at length in "Anatomical Terminology" (W. & G., '89).

§67. V. 1895-1896. Among the requirements of technical terms enumerated in 1871 was "Independence of Context for Signification." The rigid application of this would exclude all homonyms (§23,) and would require every term to be absolutely explicit. It was perhaps not unnatural for a comparative beginner in the subject to make such a rule, and, having made it, to adhere to it somewhat persistently as in the following cases (§§68-70).

§68. Of the three current appellations, *conarium, epiphysis* and *corpus pineale,* the last was rejected unhesitatingly as a polyonym, and the second as applying equally (without the qualifier *cerebri*) to the separable end of a growing bone; as recently acknowledged ('96, *b*). I long resisted the precept and example of H. F. Osborn and E. C. Spitzka in favor of *epiphysis* as correlative with *hypophysis,* and failed to recognize the full force of Dall's remark, "The human mind wearies of too many names and much more readily assimilates a new meaning for an old one," although it was printed as Aphorism XV in W. & G., '89, p. 520.

§69. Likewise, although favoring the general plan of rendering the Latin *ae* and *oe* by *e* in Anglicised (paronymized) words,[1] I retained the diphthong in *coelia* and its compounds

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[1] In this country no medical writer has more persistently and vigorously urged this simplification than the former editor of the (Phil.) *Medical News* Gould, G. M., '94, '96.

(from *κοιλία*, a cavity) for the sake of distinguishing them from the derivatives of *κήλη*, a tumor. I now frankly acknowledge the non-necessity of the diphthong even for the discrimination of *encephalocele*, the normal cavity of the brain, from the same word signifying an abnormal protrusion of the organ.[1]

§70. In August, 1884 ('84, *a*, 114) I proposed to replace the common polyonym *axis cerebro-spinalis*, and even Owen's *myelencephalon*, by the brief mononym *neuron*, warranted by *neuralis*, *neurenterica*, etc. and correlated with *enteron* (*canalis alimentaria*) and *axon* (*axis somatica*). The term was used by Minot ('92, 606); Stowell ('85); Waters ('91, 362) and others. Its abandonment by me in favor of *neuraxis* ('89, *a*) was due to two later observations: (*a*) the prior use of *neuraxis*[2] in the same sense: (*b*) the prior application of *neuron* to a part of an invertebrate eye. I have since been led to believe that I was unduly influenced by these considerations. Unfortunately the matter is now complicated by (*a*) the application of *neuron* to the entire nerve-cell including its processes, and (*b*) the designation of the "axis-cylinder process" by *neuraxon*, easily confounded with neuraxis.[3] I have already declared ('93, 100, '95, *c* '45) my lack of personal feeling in the matter, but the more I think of it the greater appear to me the advantages of *neuron*. In view of the practical efficiency of "contextual explicitness" (§26), its "invertebrate" use may be ignored, and where there could be any doubt as to whether *neuron* referred to the entire nervous axis or only to one of its histologic constituents *macroneuron* and *microneuron* might be employed. Cases not strictly analogous, and yet worthy of note in this connection are the general use of *body* and *belly* for parts of a mus-

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[1] Those who are interested in vicissitudes of opinion may think I ought to admit that for a certain intermediate period the *e* alone was used in the paronyms of *coelia*; '84, *a*.

[2] In the "Dictionnaire de Medicin" of Robin and Littré occurs *nèvraxe*, the Galloparonym of a potential antecedent, *neuraxis*; but neither the propounder nor the first adopter is named.

[3] For some history and discussion of these and kindred terms see the papers of Fish ('94) and Baker ('95).

cle; and of *tarsus* and *cilium* in both macroscopic and microscopic senses. Whatever may be the outcome I shall always regret the confusion arising from what I now regard as a manifestation of excessive conscientiousness.

§71. *Terms Withdrawn.*—Through ignorance, misapprehension, timidity, or over-confidence, I have at various times proposed or employed needless or objectionable terms. Their formal withdrawal is here made in accordance with a conviction which was expressed ('91,*a*) five years ago: "Since every one makes mistakes, the interests of all concerned would be subserved by the adoption of the custom of each correcting his own, either as soon as discovered or periodically; a sort of scientific confession of sins. The natural corollary to this would be that each well-disposed discoverer of another's fault would inform him privately so that he might make prompt correction. This plan I have followed in several cases, and have reason to believe it has served to avoid personal irritation and the needless repetition of criticism."

§72. The following terms are hereby withdrawn: *Hypocampa* (for *hippocampus* [*major*]); W. & G., '86, 400*b;* Spitzka, '84; Vicq d'Azyr, 1786, 61, *et seq.* *Torus* (for *tuber* [*cinereum*]). *Lemum* (for *torcular* [*Herophili*]; '84). *Cerebrocortex* (for *cortex cerebri* or *cerebral cortex*). *Cerebellocortex* (for *cortex cerebelli* or *cerebellar cortex.* *Commissure habenarum* (for *supracommissura*); W. & G., '86, 400*b.* *Mediventricle* (for "third ventricle"); '80, *d* *Lativentricle* (for "lateral ventricle"); '80 *d.* *Procele* (for paracele); '84, *c;* W. & G., '86, 400*b.* *Coele* and its compounds (for cele and its compounds); (§69).

§73. If the foregoing list of my verbifactive sins appears damagingly large, let the critics scan their own records with equal closeness; I have at least been consistent within the limits of a single publication.

§74. Fifteen years ago I was so oppressed by the length and obtrusive Latinity of the current names for the segments of the brain, *prosencephalon, etc.*, as to suggest ('81, *b*) that they might sometimes be abbreviated to *prosen.*, etc. Three years later, in accordance with the analogies of *quad* (for *quadrangle*), *grog* (for *grogram*), *photo* (for *photograph*), *stereo* (for *stereotype*), and *consols* (for *consolidated annuities*),[1] I ventured ('84, *b*) to drop the sign of abbreviation and to use these *verba decaudata* as real words. Their withdrawal a year afterward ('85*b*, 354) may have been due partly to the horror of some anatomic friends in whose eyes they were needless and indefensible "nicknames;" but I was influenced mainly by the revulsion attendant upon the formulation of the principle of paronymy whereby the shorter *prosencephal*, etc., were legitimized. Yet I anticipate the eventual rehabilitation of the abridged forms.

§75. *Acknowledgements.*—I have had more or less frequent conference or correspondence with nearly all the members of the four committees named elsewhere (§§80-84) and with other scientific or literary authorities. Only by investigators, teachers, and practitioners equally eminent, preoccupied, and familiar with current terminology, can it be wholly realized what it meant for these men to give prompt and full attention to queries and propositions that threatened to disturb the verbal basis of their intercommunications. Reviewing the experience, I am amazed at the uniform readiness and kindliness of the responses[2] and can truly say that even when not wholly or directly encouraging they were always fruitful. To four men are due particular acknowledgements.

§76. As student (1873-1877), as assistant (1875-1880), as colleague (since 1880) and as collaborator ("Anatomical Technology," 1880-1892; "Anatomical Terminology," 1888-1889) Simon H. Gage has been constantly and preeminently helpful.

§77. Edward C. Spitzka (§80, note) one of the most learned, progressive and productive American neuro-anatomists, generously entertained the new terms ('81), adopted some, and for others proposed improvements; nay, this undaunted upholder of an unpopular opinion in a period of intense political

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[1] The last case to meet my eye is *hippos* for *hippopotami* (The *Nation*), 1896; verily "the slang of one age may become the purism of the next."

[2] Their nature made it the easier to meet with equanimity the few attempts to check terminologic progress by ridicule. For the response to one of these see my paper '86, *f*.

excitement[1] went so far as to say that some of my suggestions had been long in his own mind but that he had "lacked the courage to bring them before his colleagues." Dr. Spitzka's cordial interest has never abated, and I only lament that more practical duties leave him less time now than formerly for research in the anatomy of the brain.

§78. I have already expressed (W. & G.,'89, §2 note) my appreciation of the erudition and kindness of my colleague in Comparative Philology, Benjamin I. Wheeler. Aside from information imparted at personal interviews, the etymologic and linguistic points upon which he has enlightened me cover nearly one hundred of the "correspondence slips."[2]

§79. To quote his own words, "The last thing an old teacher wants is a new set of terms for a familiar set of objects." Yet this did not prevent Oliver Wendell Holmes, then for the third of a century professor of Anatomy in the Harvard Medical School, from writing, May 3, 1881, a letter containing the following passages:

> "I have read carefully your paper ['81 *b*] on Nomenclature. I entirely approve it as an attempt. I am struck with the reasonableness of the system and the fitness of many of the special terms. The plan is an excellent one; it is a new garment which will fit Science well, if that capricious and fantastic and old-fashioned dressing lady can only be induced to try it it on." The entire letter is printed on pp. 11-12 of (W. & G., '82). It was a source of comfort to me and doubtless led many to consider seriously suggestions that might otherwise have been ignored or repelled.

Part III. Action of the American Neurological Association.

§80. On the 5th of June, 1896, at a regular meeting in Philadelphia, the American Neurological Association adopted

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[1] As an expert at the trial of Guiteau he held the mental constitution of the assassin to be abnormal; see *Alienist and Neurologist*, 1883, April *et seq.*

[2] For the use of slips in correspondence see W. and G., '86, 52 and *Science*, Jan. 16, 1885, p. 44.

unanimously the "Report of the Committee on Neuronymy."[1] The recommendations were as follows:

1. That the adjectives DORSAL and VENTRAL be employed in place of *posterior* and *anterior* as commonly used in human anatomy, and in place of *upper* and *lower* as sometimes used in comparative anatomy.

2. That the cornua of the spinal cord, and the spinal nerve-roots, be designated as DORSAL and VENTRAL rather than as *posterior* and *anterior.*

3. That the costiferous vertebrae be called THORACIC rather than *dorsal.*

4. That, other things being equal, MONONYMS (single-word terms) be preferred to *polyonyms* (terms consisting of two or more words).

5. That the *hippocampus minor* be called CALCAR; the *hippocampus major,* HIPPOCAMPUS; the *pons Varolii,* PONS; the *insula Reilii,* INSULA; *pia mater* and *dura mater,* respectively PIA and DURA.

6. That the following be employed rather than their various synonyms: HYPOPHYSIS, EPIPHYSIS (for *conarium* and *corpus pineale*), CHIASMA, OBLONGATA, LEMNISCUS, MONTICULUS, TEGMENTUM, PULVINAR, FALX, TENTORIUM, THALAMUS, CALLOSUM, STRIATUM, DENTATUM, MESENCEPHALON, PALLIUM, OLIVA, CLAVA, OPERCULUM, FISSURA CENTRALIS (for *f. Rolando,* etc.), F. CALCARINA, F. COLLATERALIS, F. HIPPOCAMPI, CUNEUS, PRAECUNEUS, CLAUSTRUM, FORNIX, INFUNDIBULUM, VERMIS.

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[1] The committee was appointed by the President of the Association, upon the suggestion of the writer, at the regular meeting in New York city, June 20, 1884. One of the most interested of the original members, Dr. W. R. Birdsall, has since died. It now comprises Henry H. Donaldson, Ph.D., professor of Neurology, Chicago University; Landon Carter Gray. M.D., professor of Nervous and Mental Diseases, New York Polyclinic; Charles K. Mills, M.D., professor of Diseases of the Mind and Nervous System in the Philadelphia Polyclinic; Edward C. Seguin, M.D., professor of Diseases of the Mind and Nervous System in the Medical Department of Columbia University; Edward C. Spitzka, M.D., formerly professor of the Anatomy and Physiology of the Nervous System in the Post-graduate Medical School of New York city; and B. G. Wilder, Chairman.

§81. Sections 1, 2, 3, and 5 constituted the "Preliminary Report of the Committee on Anatomical Nomenclature" of the Association of American Anatomists which was adopted unanimously by that body Dec. 27, 1889.[1]

§82. Section 4 is substantially identical with the second paragraph of the "Second Preliminary Report" of the same Committee,[2] viz., "Your Committee recommend to anatomists that, other things being equal, terms consisting of a single word each be employed rather than terms consisting of two or more words." *Proceedings* for 1895, p. 4.

§83. Section 4 is also substantially represented in the "Third Preliminary Report of the Committee on Anatomical Nomenclature with special reference to the Brain" [3] which was adopted unanimously by the American Association for the Advancement of Science, Sept. 2, 1889:— "They agree upon one point, *viz.*, the advantages, other things being equal, of mononyms (single-word terms) over polyonyms (terms consisting of two or more words)." The report was published in the *Proceedings* for 1889, p. 26.

Sections 1, 2, 3, 5, occur *verbatim* in the Fourth Report of the same committee which was adopted unanimously by the Association Aug. 25, 1890 and printed in the *Proceedings*, p. 20.

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[1] The members of the committee at that time were Joseph Leidy, M.D., L.L.D., professor of Anatomy in the University of Pennsylvania, president; Harrison Allen, M.D., formerly professor of Physiology in the U. of P.; Frank Baker, M.D., professor of Anatomy in the Medical Department of Georgetown University; Thomas B. Stowell, Ph.D., principal of the Potsdam (N. Y.) Normal School; and B. G. Wilder, Secretary. To the committee, at the meeting, was added Thomas Dwight, M. D., professor of Anatomy in the Harvard Medical School. The report was published in the History and Records of the Association for 1888, 1889, 1890, p. 5.

[2] Upon the death of Dr. Leidy, Dr. Allen succeeded to the chairmanship of the Committee. The place of Dr. Stowell, resigned on account of pressing administrative duties, was filled by the appointment of F. H. Gerrish, M.D., professor of Anatomy in the Medical School of Maine.

[3] The Committee comprised, besides H. Allen, F. Baker, T. B. Stowell, and B. G. Wilder, chairman (see §81, note), Henry F. Osborn, Sc.D., professor of Biology in Columbia University.

§84. The first five sections of the report of the Neurological Committee are embodied *verbatim* in the "Preliminary Contribution of the American Branch of the International Committee on Biological Nomenclature of the American Association for the Advancement of Science"[1] which was adopted unanimously by that body Aug. 23, 1892, and published in its *Proceedings*, p. 231.[2]

§85. The report just mentioned is so clear, comprehensive, and concise that its main features are here summarized:

a. "Terms relating to position and direction [toponyms, 9] should be intrinsic rather than extrinsic; that is, should refer to the organism itself rather than to the external world."

b. "So far as possible terms should be single, designatory words [mononyms, §15] rather than descriptive phrases."

c. Terms derived from the names of persons [eponyms, §33] should be avoided.

d. "Each term should have a Latin [international, §46] form."

e. "Each term should have also a [national, §43] form in accordance with the genius of each modern language, e. g., a paronym [§44] of the original Latin form."

f. The report gives due recognition of the labors of other committees and of individuals.

§86. Returning to the report adopted by the American Neurological Association [§80] its recommendations may be indicated conveniently in the following Table I:

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[1] The members are George L. Goodale, Ph.D., professor of Natural History in Harvard University, chairman; John M. Coulter, L.L.D., president of the State University of Indiana; Theodore Gill, Ph.D., Smithsonian Institution; Charles Sedgwick Minot, Ph.D., professor of Embryology in Harvard University; Simon H. Gage, B.S., professor of Histology and Embryology in Cornell University, secretary.

[2] Reprints were distributed to biologists of all nationalities and may be obained from the secretary.

TABLE I.

Forty Latin names recommended unanimously by the American Neurological Association, June 5, 1896.

Mononyms (single-word terms)			*Dionyms*
CALCAR	HIPPOCAMPUS	PIA	CORNU DORSALE
CALLOSUM	HYPOPHYSIS	PONS	CORNU VENTRALE
CHIASMA	INFUNDIBULUM	PRAECUNEUS	FISSURA CALCARINA
CLAUSTRUM	INSULA	PULVINAR	FISSURA CENTRALIS
CLAVA	LEMNISCUS	STRIATUM	FISSURA COLLATERALIS
CUNEUS	MESENCEPHALON	TEGMENTUM	FISSURA HIPPOCAMPI
DENTATUM	MONTICULUS	TENTORIUM	RADIX DORSALIS
DURA	OBLONGATA	THALAMUS	RADIX VENTRALIS
EPIPHYSIS	OLIVA	VERMIS	VERTEBRA THORACALIS
FALX	OPERCULUM		
FORNIX	PALLIUM		

§87. *Cerebellum* might well have been added to the list for there is no disagreement as to the application of the word. *Cerebrum,* unfortunately, is used in at least two senses, (*a*) as equivalent to the prosencephal, and (*b*) as including also two or three adjoining segments.

§88. Of the forty terms in the above list thirty-one are mononyms (§15). The other nine, nearly one-fourth, are dionyms (§13). This fact is to be noted in connection with certain animadversions of the German committee (Part V).

§89. In Table II are given in parallel columns (1) the Latin (international) names adopted by the American Neurological Association; (2) their English paronyms; (3) the regular Latin adjectives; (4) the English forms or paronyms of the Latin adjectives.[1]

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[1] Had space permitted I should have been glad to amplify this table after the pattern of that upon pp 530 and 531 of W. & G., '89. Forty-five terms were there given substantially as in the following example:

LATIN

(Common polyonym in upper line.)

Nom. singular	Genitive	Nom. plural	Adjective
	Thalamus nervi optici		
Thalamus	*Thalami*	*Thalami*	*Thalamicus*

ENGLISH

(Heteronym in upper line.)

Singular	Plural	Adjective	FRENCH GERMAN ITALIAN
	Optic bed		
THALAMUS	THALAMI	THALAMIC	*Thalame* *Thalamus* *Talamo*

TABLE II.

Derivatives of the Terms adopted by the American Neurological Association.

	Substantives		*Adjectives*	
	Latin	*English*	*Latin*	*English*
1	Calcar	Calcar	Calcarinus	Calcarine
2	Callosum	Callosum	Callosalis	Callosal
3	Chiasma	Chiasma or chiasm	Chiasmaticus	Chiasmatic
4	Claustrum	Claustrum	Claustralis	Claustral
5	Clava	Clava	Clavalis	Claval
6	Cornu dorsale	Dorsal cornu		
7	Cornu ventrale	Ventral cornu		
8	Cuneus	Cuneus	Cunealis	Cuneal
9	Dentatum	Dentatum	Dentatalis	Dentatal
10	Dura	Dura	Duralis	Dural
11	Epiphysis	Epiphysis	Epiphysialis	Epiphysial
12	Falx	Falx	Falcialis	Falcial
13	F. calcarina	Calcarine fissure		
14	F. centralis	Central fissure		
15	F. collateralis	Collateral fissure		
16	F. hippocampi	Hippocampal fissure		
17	Fornix	Fornix	Fornicalis	Fornical
18	Hippocampus	Hippocamp or hippocampus	Hippocampi (gen.) or hippocampalis	Hippocampal
19	Hypophysis	Hypophysis	Hypophysialis	Hypophysial
20	Infundibulum	Infundibulum	Infundibularis	Infundibular
21	Insula	Insula	Insularis	Insular
22	Lemniscus	Lemniscus	Lemniscalis	Lemniscal
23	Mesencephalon	Mesencephal or mesencephalon	Mesencephalicus	Mesencephalic
24	Monticulus	Monticulus	Monticularis	Monticular
25	Oblongata	Oblongata	Oblongatalis	Oblongatal
26	Oliva	Oliva or olive	Olivaris	Olivary
27	Operculum	Operculum or opercle	Opercularis	Opercular
28	Pallium	Pallium	Pallialis	Pallial
29	Pia	Pia	Pialis	Pial
30	Pons	Pons	Pontilis	Pontile
31	Praecuneus	Precuneus	Praecunealis	Precuneal
32	Pulvinar	Pulvinar	Pulvinaris	Pulvinar
33	Striatum	Striatum	Striatalis	Striatal
34	Tegmentum	Tegmentum or tegment	Tegmentalis	Tegmental
35	Tentorium	Tentorium	Tentorialis	Tentorial
36	Thalamus	Thalamus	Thalamicus	Thalamic
37	Radix dorsalis	Dorsal root		
38	Radix ventralis	Ventral root		
39	Vermis	Vermis	Vermianus	Vermian
40	Vertebra thoracalis	Thoracic vertebra		

§90. It should be borne in mind that only the Latin names in the first column have the sanction of the various Associations that have adopted them. The derivatives and the comments thereon do not constitute parts of the reports. Indeed, as will be seen, there is room for considerable latitude of opinion and usage; my own views may be imperfect and even inconsistent, but I think the analogies adduced are sound.

§91. *English Plurals.*—The parts of the brain are so seldom named in the plural that a separate column is not given therefor. Analogy with *crises, strata, fungi, algae* and *phonomena* would justify the employment of the regular Latin plural in certain cases, e. g., *thalami, epiphyses, hippocampi, cornua, striata* and *vertebrae.* On the other hand, *areas, vistas, hernias, emporiums, lenses, geniuses, pianos, indexes, pericarps, angles, atlases, diplomas,* and *similes* are precedents for *calcars, chiasmas* (or chiasms), *falxes, hippocamps, insulas, mesencephals, ponses, vermises. Bonuses* would even justify *thalamuses* but the length of the latter is objectionable.

§92. *Close resemblance of the Angloparonyms to the Latin originals.*—This is so obvious as to hardly require mention. With more than half, the two forms are identical in spelling, so that the Latinity of the originals can only be indicated to the eye by italics, and to the ear by the pronunciation now commonly adopted for Latin words.[1]

§93. *Hippocamp.*—For this, as the Angloparonym of hippocampus, there are many precedents, notably the following:—*antepenult, digit, impediment, diagram, telegram* (which was strenuously objected to when first introduced), *epicarp* and *pericarp*; see my note as to *pericard,* '95, *a.*

§94. *Infundibulum.*—If the part so designated were frequently mentioned it is probable that either a shorter word would be found, or the present name be paronymized as *infundi-*

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[1] The Angloparonyms of Latin words, even when orthographically unmodified, are English by adoption and are to be so pronounced; to pronounce *claustrum, clowstroom* in an English sentence would be as affected as to say *mamorarndoom.* As an English word *oblongata* has the first *a* as in *mate.*

bule, after the analogy of *reticule, diverticle,* etc. The same may be said of *monticulus* and *monticule*; see §167.

§95. *Mesencephalon.*—By itself and used occasionally the Latin form is certainly euphonious and unobjectionable; but in any discussion of the segmental constitution of the brain, whether written or spoken, the frequent recurrence of the obtrusively Latin termination is pedantic and burdensome. Its omission is warranted by words like *angel.*[1]

§96. *Operculum* and *Opercle.*—The Latin tetrasyllable is not commonly oppressive, but the compounds *preoperculum* etc., might well become so. The case is comparable with that of *ultima;* with it, and even with *penultima,* the last two syllables are endured; but when two more syllables are added at one end, then two are dropped from the other, leaving *antepenult* of only moderate length. *Preopercle, subopercle* and *postopercle* are already applied to analogous parts of the fish's head; see §§67-70.

§97. *Praecuneus.*—Here the difference between the Latin antecedent and the Angloparonym consists in the replacement of the *ae* by *e* as in *preposition, pretext, preface,* etc.

§98. *Tentorium.*—By analogy with *ovary, aviary, granary, laboratory* etc., the Angloparonym would be *tentory,* and this word has been used to designate the awning of a tent. But *tentorium* is unobjectionable and likely to be retained as an unchanged paronym.

§99. *Pontilis.*—Unwarrantable forms of the English adjective from *pons* occur so frequently that there is here reproduced a paragraph from my recent note on the subject, '96, *a.* "In the subtitle of the letter above mentioned the case is referred to as one of '*pontine* hemorrhage.' This form of the adjective is not uncommon in medical literature, and *pontic* and *pontal* have found their way into the dictionaries. Now, as may be seen from any Latin lexicon, *pontal* has no justification whatever. *Ponticus,* the Latin antecedent of *pontic,* is derived from *pontus,* the sea. *Pontinus,* the antecedent of *pontine,* was orig-

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[1] Respecting the possibility of further abridgement of these terms see §74.

inally *Pomptinus*, and refers to a district of Italy. As already pointed out by me (article Anatomical Terminology, Buck's Reference Handbook of the Medical Sciences, VIII, 524, §50), the only legitimate Latin adjective from *pons* is *pontilis*, and its Angloparonym is *pontile*. The use of any other form tends to cause confusion and to bring discredit upon medical scholarship."

Part IV. Comparison of the Terms Adopted by the American Neurological Association with those Adopted by the Anatomische Gesellschaft.

§100. In the accompanying Table III are given in parallel columns (1) the forty terms adopted by the A. N. A.; (2) the corresponding terms adopted by the Anatomische Gesellschaft; (3) some of the Latin synonyms.

§101. Probably few will question the inferiority of the discarded synonyms in the third column; hence are here considered mainly the relative merits of the two other sets.

§102. The extent of agreement is impressive and encouraging. With the following twenty-four terms there is absolute consensus between the American and the German committees: Claustrum; Clava; Cuneus; Fissura calcarina; F. collateralis; F. hippocampi; Fornix; Hippocampus; Hypophysis; Infundibulum; Insula; Lemniscus; Mesencephalon; Monticulus; Oliva; Operculum;[1] Pallium; Pons; Praecuneus; Pulvinar; Tegmentum; Thalamus; Vermis; Vertebra thoracalis.

§103. With the following ten terms the differences lie merely in the retention by the Germans of certain words which the Americans regard as superfluous. In the following list these words are italicized: Calcar *avis* (§105); *Corpus* callosum (§111);

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[1] The case of this term is peculiar. The German committee particularize three parts, *frontal*, *parietal* and *temporal* of a general operculum. The Neurological Association regards the parietal portion as *the* operculum, the frontal and temporal being so specified. (By the present writer these are designated as *praeoperculum* and *postoperculum*, and the *orbital* portion as *suboperculum*.) It will be seen therefore that while the word *operculum* is identical with both committees, its significance is general with the German and special with the American.

TABLE III.

Comparison of the Terms adopted by the American Neurological Association (first column) with those of the German Committee (second column) and with certain Synonyms (third column).

1	Calcar	Calcar avis	Hippocampus minor ; Eminentia digitalis; Unguis
2	Callosum	Corpus callosum	Corpus callosum; Trabs cerebri
3	Chiasma	Chiasma opticum	Chiasma nervorum opticorum ; Commissura optica
4	Claustrum	Claustrum	Claustrum
5	Clava	Clava	Processus clavatus
6	Cornu dorsale	Columna posterior	Cornu posterius
7	Cornu ventrale	Columna anterior	Cornu anterius
8	Cuneus	Cuneus	Lobulus occipitalis internus; Lobulus cuneatus
9	Dentatum	Nucleus dentatus	Corpus dentatum cerebelli
10	Dura	Dura mater	Dura mater
11	Epiphysis	Corpus pineale	Conarium ; Glandula pinealis ; Epiphysis cerebri
12	Falx	Falx cerebri	Falx major; Processus falciformis
13	Fissura calcarina	Fissura calcarina	Fissura occipitalis horizontalis
14	Fissura centralis	Sulcus centralis	Fissura Rolandica ; S. posteroparietalis
15	Fissura collateralis	Fissura collateralis	Sulcus occipito-temporalis ; S. temporo-occipitalis
16	Fissura hippocampi	Fissura hippocampi	Fissura hippocampi
17	Fornix	Fornix	Fornix tricuspidalis
18	Hippocampus	Hippocampus	Hippocampus major ; Cornu Ammonis
19	Hypophysis	Hypophysis	Glandula pituitaria ; Hypophysis cerebri
20	Infundibulum	Infundibulum	Pedunculus hypophyseos
21	Insula	Insula	Insula Reilli ; Lobus centralis ; Median lobe
22	Lemniscus	Lemniscus	Laqueus
23	Mesencephalon	Mesencephalon	Mesencephalon
24	Monticulus	Monticulus	Monticulus
25	Oblongata	Medulla oblongata	Bulbus rhachidicus
26	Oliva	Oliva	Corpus olivare ; Nucleus olivaris
27	Operculum	Operculum (pars parietalis)	Operculum parietale
28	Pallium	Pallium	Mantellum
29	Pia	Pia mater	Pia mater
30	Pons	Pons [Varolii]	Pons Varolii ; Protuberantia annularis
31	Praecuneus	Praecuneus	Lobus quadrilaterus
32	Pulvinar	Pulvinar	Tuberculum [thalami] posterius
33	Striatum	Corpus striatum	Ganglion cerebri anterius
34	Tegmentum	Tegmentum	Tegmentum caudicis
35	Tentorium	Tentorium cerebelli	Tentorium
36	Thalamus	Thalamus	Thalamus opticus; T. nervi optici; Ganglion cerebri posterius
37	Radix dorsalis	Radix posterior	Radix posterior
38	Radix ventralis	Radix anterior	Radix anterior
39	Vermis	Vermis	Vermis bombycinus; Processus vermiformis
40	Vertebra thoracalis	Vertebra thoracalis	Vertebra dorsalis

Chiasma opticum (§109); *Nucleus* dentatus (§123); Dura *mater* (§116); Falx *cerebri* (§124); *Medulla* oblongata (§116); Pia *mater* (§117); *Corpus* striatum (§115); Tentorium *cerebelli* (§125).

§104. With the remaining six terms the differences are more or less radical (§§119-122, 127-133).

§105. CALCAR versus *calcar avis.* Thirty years ago, in connection with the controversy as to the cerebral peculiarities of man, the term *hippocampus minor* became familiar even to general readers. Nevertheless, probably influenced in some degree by Huxley's proposition to replace Owen's *posthippocampal* and Henle's *occipitalis horizontalis* by *calcarina*,[1] anatomists have been more and more generally employing *calcar avis*, and this is adopted by the German committee in preference also to *unguis* and *eminentia digitalis.* The advantages of correlated names (§32) for collocated parts are many and great, as illustrated by *hippocampus* [*major*] and *fissura hippocampi;* by *eminentia collateralis* and *fissura collateralis.* In the present case these advantages would have been gained equally had Huxley adopted Owen's *posthippocampal* for the fissure and proposed *posthippocampus* for the ental ridge corresponding thereto. Indeed this would have been in accordance with the general principle of locative names (§29) and learners would have been spared thereby some effort of memory. In this, however, as in so many other instances it is now idle to speculate upon the consequences of harmonious coöperation between the two leaders of English anatomy at that period. Assuming that *calcar avis* has general and decided preference over the other names enumerated, there need be stated here only the grounds upon which *calcar* has been unanimously adopted by four American Committees and by the three associations which they represent.

§106. Briefly, the adoption of *calcar* is a logical corollary of the recommendation which is common to the reports of all

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[1] Pye-Smith wrote as follows nearly twenty years ago ('77): "Of all the synonyms of *hippocampus minor*, *calcar avis* is the most distinctive and brings it at once into relation with the calcarine fissure."

four American committees, viz., "Other things being equal, it is recommended that mononyms be preferred to polyonyms." *Calcar avis* is a polyonym ; *calcar* is a mononym.

If it be said that *unguis* is also a mononym, the answer is that in this case "other things" would not be equal, because (1) no general preference has ever been shown for it or for any term of which it is a constituent; (2) there would be lost the advantage of the correlation now existing between the ental ridge and the fissure collocated therewith.

§107. Two objections might be offered to the omission of the qualifying genitive, *avis*.

1. The original sense of the Latin *calcar* was *spur*, and its application to the sharp projection on the leg of the cock was metaphoric. This can hardly be entertained as a serious objection; indeed, although the modern spur has a toothed wheel or rowel, the primitive instrument was little more than a spike; hence the qualifying genitive is needless.

2. *Calcar* has also been applied occasionally to two other parts, viz., the calcaneum (os calcis) and the styloid process of the temporal bone. But, (*a*) neither of these uses is sanctioned by the German committee, and (*b*) even if they were, the context would infallibly avert misapprehension (§§23, 67); indeed, the German committee apply *clivus* without qualification to features of two adjacent cranial bones, the occipital and sphenoidal.

§108. Finally, the sufficiency of the mononymic substantive, *calcar*, is practically conceded by all who employ the mononymic adjective, *calcarinus*, in any of its Latin inflections, or in any of its national paronymic forms. The simplest requirements of logic present the following dilemma: If *calcarinus* is sufficiently distinctive, so is *calcar* from which it is derived. But if *calcar avis* is essential, then the adjective should be *calcari-avianus* or some such compound. See also under *dura* (115). There seems to have been little if any hesitation on the part of the German committee in adopting *fissura calcarina* (His, '95, 170) and no reason for the maintenance of *calcar avis* has yet come under my notice.

§109. *CHIASMA* vs. *Chiasma opticum.*—Meynert's *chiasma nervi acustici* is not retained by the German committee, and even if it were there is no likelihood of confusion with it or with Camper's *chiasma tendinum.* *The* chiasma is and always will be that of the optic nerves. The use of any qualifier suggests undesirable variations like *chiasma nervorum opticorum* and *commissura optica.* Furthermore, the sufficiency of the unincumbered mononym is practically conceded by the German committee in designating one of the subarachnoid spaces as *cisterna chiasmatis*; see also His, '95, 171, line 8[1].

§110. *THALAMUS.*—This term may naturally be mentioned here. In the German list the adjective *opticus* is omitted, and His makes the following remark ('95, 7, lines 1-3): "Wir stimmen unsererseits völlig bei, wenn das Wort Thalamus kurzweg an die Stelle von Thalamus opticus gesetzt wird." But it is worthy of note that *thalamus* is strictly an idionym (§24), and that the only valid excuse for the addition of the adjective is a desire to aid the student's memory by the association with the optic nerve. As a matter of fact, no case of real advantage is known to me, and the frequent repetition of the adjective may easily become a burden, as pointed out by me in 1888 ('88, *b*).

§111. *CALLOSUM* vs. *corpus callosum.*—*Corpus callosum* is the most familiar type of a large group of anatomic names. In 1889, including unusual synonyms, I recorded one hundred neural polyonyms of which *corpus* constituted the initial word. Ten such remain upon the German list, (viz., *corpus restiforme*; *cp. trapezoideum*; *cp. medullare*; *cp. quadrigeminum*; *cp. mamillare*; *cp. geniculatum mediale*; *cp. gnc. laterale*; *cp. pineale*; *cp. callosum*; *cp. striatum*), and their genitives are correspondingly in evidence.

§112. It must be admitted that *corpus callosum* is rather attractively sonorous. It is easily pronounced and even, like *quadrupedante*, "runs trippingly from the tongue."[2] But that is

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[1] The word *chiasma* is discussed at some length by Hyrtl, '80, 105-106.

[2] A similar concession has been made (*Science*, June, 22, 1888, editorial) to the claims of proper names like *Johnny McWhorter* which are euphonious and easily remembered.

no reason for the retention of a word which is not merely needless, but really burdensome by reason of the frequency with which certain parts are mentioned. In one short paper (*Brain*, October, 1885, 377-379) *corpus callosum* occurs twenty times, an average of once in five lines; *corpus* occupies 2.5 lines, one-fortieth of the entire paper.

§113. The elimination of *corpus* from all neural names constituted one of the fundamental propositions of my first communication upon the general subject ('80, *f*), and since that time it has been consistently practised and persistently preached.

§114. By the use of the genitive case, *corporis callosi*, the German committee have designated the various divisions of the callosum, (splenium, genu, truncus and rostrum); also the sulcus along its dorsal margin. They have thus avoided the use of the secondary adjective *callosalis*. But in expressly rejecting *pedunculus corporis callosi* in favor of *gyrus subcallosus* (His, '95, 170-172) they practically concede the superfluity of the *corpus*.

§115. Unless we are prepared to abandon all adjective-substantives (§118) there seems to be no reason for the further retention of *corpus* in any of the terms enumerated in §111. *Corpus fornicis* of the German list is not open to the objection that naturally arises against *corpus corporis callosi* but *truncus corpus callosi* is a good precedent for *truncus fornicis* if the distinction be necessary.

§116. *DURA* vs. *dura mater.*—This constitutes a type and test case for a considerable group of anatomic terms from which, for fifteen years, I have dropped the (here italicized) nouns, viz., pia *mater; substantia* alba; *substantia* cinerea; *membrana* (or *tunica*) serosa; *mb.* (or *tn.*) mucosa; *mb.* (or *tn.*) submucosa; *mb.* (or *tn.*) arachnoidea; *medulla* oblongata. From the group of "corpus" polyonyms they differ in that the elimination of the substantive leaves a feminine instead of a neuter adjective to be used substantively, and as a base for the formation of secondary adjectives, *dural, mucosal, cinereal, arachnoidal,* etc.

§117. Curiously enough the first precedent for this known to me dates back a hundred and fifty years. In the "Medical Dictionary" of James (1743), in the article "cerebrum", occurs the following sentence: "The superficial vessels of the cerebrum are lodged between the two laminae of the pia."

§118. The employment of the mononymic feminine adjectives as substantives, and of the secondary adjectives derived therefrom, has now become so general[1] that the matter would hardly need discussion but for the reactionary attitude of the German committee. Yet this attitude is really not maintained consistently. *Cornea* is a feminine adjective. So is *sclera.* In *arachnoidea encephali* the feminine adjective is used as a noun. *Muscularis mucosae* and *tela submucosa* are warrants for *mucosa*, etc. Finally, although the useless noun is retained in *dura mater spinalis* and *filum durae matris spinalis*, the very next terms in their list, *cavum epidurale* and *cavum subdurale*, are indirect and probably unintended, yet none the less complete, precedents for *dura* pure and simple, and for the substantive employment of any and all feminine adjectives whatsoever.

§119. *EPIPHYSIS* vs. *corpus pineale.*–His regards *epiphysis* as a "generelles Wort" ('95, 163) and the ancient dionym is adopted by the German committee.[2] My own earlier preference was for *conarium*, as stated in §68. I now realize the desirability of the verbal as well as the topographic correlation with *hypophysis* and *paraphysis*, and the inutility of maintaining in all cases the rigid doctrine of 1871 (§67).

§120. *FISSURA CENTRALIS* vs. *sulcus centralis* (or *fissura* or *sulcus Rolando*).—By comparison of the three columns it will be seen that two distinct points are concerned, involving respectively the generic and the specific names of this feature of the lateral aspect of the cerebrum. If eponyms or personal names are to be abandoned, as decided by the German commit-

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[1] In Foster's Medical Dictionary, *dura* and *pia*, *dural* and *pial*, are major headings, *dura mater* and *pia mater* being merely synonyms.

[2] In the earlier publication (*Science*, July 17, 1896, p. 71) of the report of the Neurological Committee, the date, *1895*, after *epiphysis* would indicate its adoption by the Germans. That was an error for which I must be held responsible, and which was corrected as soon as possible after it was noted; '96, *b*.

tee and as advocated by me since 1880,[1] then all the derivatives of *Rolando* must be discarded in favor of *centralis* and its derivatives. Those who prefer the eponym should show that Rolando's figure and description really merit such commemoration, and should be also at least consistent in the employment of derivatives. *Paracentralis*, *praecentralis* and *postcentralis* have no other justification than topographic reference to *centralis*; yet it is by no means uncommon to find in one and the same paper "fissure of Rolando" and "paracentral lobule."

§121. As to the generic terms, *fissura* and *sulcus*, the former has been consistently employed by me since 1880 for all linear depressions of the cerebral surface, while the German committee restrict it to the sylvian (called by them *cerebri lateralis*), the collateral, the occipital (their parieto-occipitalis) the calcarine and the hippocampal, and name all the others *sulci*. They regard the striatum as constituting an ental correlative of the sylvian (p. 170); hence it may be inferred that *fissura* indicates a corrugation of the entire parietes, while *sulcus* indicates a linear furrow not represented in the cavity by a corresponding elevation.[2] Fully conceding the desirability of recognizing the distinction between the two groups of cerebral furrows, the following considerations lead me to question the advisability of employing the two generic words in the senses proposed by the German committee.

(1). *Fissura* and its various paronyms and heteronyms are already well established and commonly associated with cerebral topography. This subject, on account of its various relations, physiologic, pathologic, surgical and psychologic, has already gained much general interest. *Sulcus* is a comparatively unfamiliar word. It is distinctively Latin and technical. Its Latin plural, *sulci*, is even more so. It does not readily lend itself to

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[1] With the exception of *fissura Sylvii* and certain derivatives of *sylviana*.

[2] The two groups are sometimes distinguished as *total* and *partial*, or as *complete* and *incomplete*. The former seem to be preferable, since with the total the totality of the parietes is involved, whereas *complete* and *incomplete* seem to imply differing degrees of relative perfection.

paronymization, *sulc* and *sulcuses* being both somewhat unacceptable.

(2). *Sulcus* has recently been employed by Mrs. Gage ('93), O. D. Humphrey ('94), P. A. Fish ('94), and B. F. Kingsbury ('95), for ental (entocelian or intraventricular) depressions which are less likely than the cerebral furrows to become subjects of general interest.

§122, (3). There is a practical difficulty that cannot be ignored. Nothing in the words *fissura* and *sulcus*, or in their ordinary associations, serves to admonish us as to the proposed distinction. Hence there is liability to misuse and confusion. Many actual instances of this might be cited but the following may suffice. Edinger ('95) apparently intends to apply *fissura* to the total fissures, and the occipital is so designated in the index; but on Fig. 33 it is called *sulcus.* Kölliker ("Entwickelungsgeschichte," p. 555) attributes *sulcus calcarinus* to Huxley, who uses *fissure* as does Kölliker in the explanation of a figure. Flower ("*Proteles*," *Zool. Soc. Proc.*, 1869) applies to the supraorbital, *fissura* and *sulcus* indifferently. Huxley ("Vertebrated Animals") says that the cerebral surface becomes complicated by ridges and furrows "the gyri and sulci;" but the first of the "sulci" to be mentioned is the "sylvian fissure" and the second "the fissure of Rolando," the latter also being designated on Fig. 21 as the "sulcus of Rolando." Flower and Lydekker (Mammals, p. 71) say "the sylvian fissure is one of the most constant of the sulci. In the last two cases the generic designation of the shallower furrows is made to include both kinds, and curiously enough this usage is apparently sanctioned by the German committee in introducing *gyri cerebri* and *sulci cerebri* as comprehensive names and then specifying certain sulci and fissurae; see Table VII, II, 10, 17, 26.

§123. *DENTATUM* vs. *Nucleus dentatus.*—Two separate questions are involved in the choice between these terms: (*a*) The use of *nucleus* (with a masculine adjective) in place of *corpus* (with a neuter); (*b*) The employment of an adjective of either gender as a substantive. The latter is considered in connection with *collosum* and *dura* (§§111-118). The substitution of *nucleus* for *corpus* seems to the American committee to constitute a step backward, as tending to obscure the commonly accepted distinction between the part in question, with the analogous part in the oliva on the one hand, and the "nuclei"[1] of origin of the various nerves on the other.

§124. *FALX* vs. *Falx cerebri.*—The German committee designate the slighter fold of dura between the two lateral masses of the cerebellum as *falx cerebelli.* The present writer prefers the diminutive, *falcula.* The American committee has not yet passed upon this case. Even should they retain *falx cerebelli* it would not prove a serious burden, because the part is hardly mentioned once while the cerebral septum is named ten times.

§125. *TENTORIUM* vs. *tentorium cerebelli.*—This case is even stronger than that of falx, for tentorium is an idionym (§24).

§126. *STRIATUM* vs. *Corpus striatum.*—See *callosum,* (§111).

§127. *CORNU DORSALE* vs. *columna* (*grisea*) *posterior.*—Two distinct issues are involved here: (*a*) toponymic, between *posterior* and *dorsalis*; (*b*) organonymic, between *columna* and *cornu.* The former will be considered in connection with *cornu ventrale* (§131) and *radix dorsalis* (§132).

§128. *CORNU* vs. *columna.*—It is almost embarassing to find myself advocating the maintenance of ancient and general usage against one comparatively novel. Probably most anatomic teachers will sympathize with the German committee in their objection to the application of *cornu* to what is really one of several ridges of a deeply fluted column of gray nervous tissue constituting the core of the "spinal cord;" ridges that resemble "horns" only when artificially exposed upon transection. At least ten years ago I was so deeply impressed by this inappropriateness of *cornu* as to hunt up an architectural term, namely *arris,* signifying the ridge between two adjoining channels of a Doric column. Whether or not it was derived from *arista,* it is excellent Latin in form, and acceptable in every respect save its novelty.

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[1] The question of preference between *nucleus*, and *nidus* (Spitzka) and *nidulus* (C. L. Herrick), need not be considered upon the present occasion.

§129. Yet I believe that I did well to refrain from its introduction; for, after all, in nine cases out of ten, the artificial appearance presented upon section is what is first offered the student, and I have never known a case of misapprehension occasioned thereby. Upon the whole, this has seemed to the American committee a good case for the observance of Huxley's aphorism ('80, 16) as to the unadvisability of interfering with terms that are well established and have a definite connotation, even when they may be etymologically inadequate, e. g., *callosum.* Individually, I should feel that the case against *cornu* would be much stronger were it a word of half a dozen syllables, or lacking in euphony.

§130. The assignment of *columna* to the ridges of the myelic cinerea naturally involved the replacement of that word, as commonly applied to the intervening masses of alba, by some other word; the German committee selected *funiculus.* If *cornu* be retained, *columna* will be available as hitherto. Even if a change be made, however, why not *funis* instead of the longer diminutive, upon the grounds stated in §21? There could hardly be confusion with the same word as applied to the "umbilical cord."

§131. *CORNU VENTRALE.*—As an objection to this term it might be urged that consistency would involve the application of the same words to the "middle" or "descending" extension of the "lateral ventricle," which the German committee call *cornu inferius.* What the American committee may do in this connection remains to be seen. There would be no real cause for ambiguity, however, since *cornu temporale, c. frontale*, and *c. occipitale* are perfect examples of a class of terms that suggest parts or regions already familiar. Personally I have never had any difficulty, the locative, mononymic, idionyms (§§25, 27) *medicornu, praecornu* and *postcornu*, having been consistently employed by me for fifteen years ('81, *b. d*).

§132. *RADIX DORSALIS* vs. *radix posterior.*—Since, with this and with *radix ventralis* (or *anterior*) the Americans and the Germans are at one as to the substantive element, there only recurs the toponymic difference already alluded to in connection with the ridges of the myelic cinerea (§127). The difference is far reaching and literally radical. As with the myelic sulci, columns, cornua and commissures, the folds of the axilla, the aspects of the thigh, the tubercles of the cervical vertebrae, the sides of the stomach and other viscera, the valves of the heart, there is exemplified one of the most undesirable features of the pernicious influence of anthropotomy upon anatomy at large.[1]

§133. Upon this subject the position of the German committee in 1895 is indicated by the following translation of passages from His, ('95, 109-110): "As mentioned above, Herr von Kölliker has proposed replacing generally the words *anterior* and *posterior* by *ventralis* and *dorsalis* where the relations to comparative anatomy, and especially to the anatomy of domesticated animals, render it desirable; that is, where the terms *anterior* and *posterior* apply only to the upright attitude of man. * * * We do not deny the merit of such strict usage, but the commission has not been able to decide upon its adoption. It involves all kinds of difficulties and inconveniences. * * * We leave time to determine whether or not we shall depart from the traditional usage associated with the erect attitude of man."

Had most of the members of the commission been investigators and teachers of zoötomy rather than of anthropotomy, there would probably have been no hesitation in adopting terms that apply equally well to all vertebrates in any attitude. Let us hope that the distinguished President of the Commission may live to see his recommendations unanimously adopted.

§134. I close this discussion of the differences between the recommendations of the American and German committees with the remark that, strictly speaking, not one of the words in the first column of Table III can be imputed to us. All were in use for longer or shorter periods prior to 1880. Com-

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[1] "The influence of the nomenclature of human anatomy, reflected downward upon the dawning structures of the lower animals which culminate in man, is nowhere more obstructive to a plain and true indication of the nature of parts than in regard to those of the brain." Owen, '61, I, 294, note.

parison with the second and third columns will show that in most cases our office was merely to disencumber the essential elements of prexisting terms from superfluous accessories.

Part V. Reply to the Criticisms offered by the Anatomische Gesellschaft or its Members upon the Terminologic Propositions or Usage of American Committees or Individuals.

§135. In the introduction to this article (§3) it is intimated that certain "German declarations against the efforts of the American committees may be due in part to ignorance or misapprehension of the facts." How far these mental conditions might have been avoided may be judged from the following statements.

§136. As mentioned in Part II, even if my earlier formulation of principles and specific suggestions (1871-1879) be disregarded, in and after 1880 papers referring directly to anatomic or neurologic nomenclature were published in periodicals presumably accessible to anatomists everywhere.[1] The appointments of the committees of the American Neurological Association and of the American Association for the Advancement of Science (§§80-84) were duly announced in medical and scientific journals, and in the transactions of the two associations. A brief preliminary report of the A. A. A. S. committee was printed in the *Proceedings* of the Association for 1886 (p. 56).

§137. The "Nomenclatur Commission" of the Anatomische Gesellschaft was appointed in 1889. Primarily German (His, '95, 3), additions were made in the following year from England, France and Italy.[2] According to His ('95, 6, 7) coōperation was also asked from Thane, Duval and Testut. Although the Anatomische Gesellschaft contains some American

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[1] To what extent reprints of those papers were sent to German anatomists at that time, I am unable to determine.

[2] Its final composition was as follows: A. von Kölliker, president; O. Hertwig, W. His, Kollman, Merkel, Schwalbe, Toldt, Waldeyer, Bardeleben, Henke, von Mihalkovics, Rüdinger, von Kupffer, Turner, Cunningham, Leboucq, Romiti, and W. Krause, secretary. This list was furnished me by the secretary in April, 1892.

associates, none, so far as I know, was invited to serve on the committee. If the omission was remarked by others, they probably, like myself, attributed it to the geographic interval.

§138. In the fall or winter of 1890 I received from the secretary, Prof. W. Krause, a letter (since mislaid) reading substantially as follows: "I have an idea that something as to Anatomical Nomenclature has been done in America. Please to send me copies of Reports and other documents."

§139. In response there were promptly sent copies of all the Preliminary Reports together with my papers and lists up to date. Their receipt was acknowledged by Dr. Krause Dec. 29th., 1890, and later in the following:

Göttingen, Apr., 15, 1891.

Dear Mr. Wilder:

I have received your papers with many thanks; if possible please to send me some ten further copies of your two pages on polyonyms, heteronyms etc., of the brain; ["Handbook," VIII, 530, 531]. You will receive upon my part after some weeks a complete copy of all the proceedings of the European committee on Anat. Nomenclature.

With kind regards,

W. KRAUSE.

P. S. I have reprinted your Preliminary Report in the *Monthly International Journal of Anat.* 1891, Vol. VII, No. 5 a. 6, p. 239.

§140. My answer was as follows:

Ithaca, N. Y., Apr., 30, 1891.

Prof. W. Krause, Dear Sir:

In response to yours of April 15th, I take pleasure in sending by bookpost copies of the sheet named, and also copies of printed lists, and of figures prepared for my students exemplifying the use of the names. We have commonly employed the English paronyms of the Latin words, but the latter are given in the "Macroscopic Vocabulary" ['90, *h*]. You do not speak of having seen my articles in the "Reference Handbook." Perhaps the work has not been introduced abroad: since, however, they present my last views as to the principles of Nomenclature, and also apply those principles to the brain, I desire that your committee should consult them. In a separate roll will go by bookpost a copy in sheets to be kept while of service to the committee. Permit me to ask attention especially to the paragraphs on pp. 522 [§45] and 532 [§82.]

Very cordially yours,

B. G. WILDER.

P. S. The photographs are of a column in the same volume, VIII, of the Handbook, in W. Browning's article on the vessels of the brain. He accepts and applies the principles of mononymy and paronymy.

§141. Later, March 27, 1892, I wrote:

> "In my letter of April 30, 1891, I announced that I should mail you a copy of the sheets of the article "Anatomical Terminology" from the eighth volume of the Reference Handbook of the Medical Sciences, published in 1889. I do not find record of its reception. If it was lost in the mail[1] I will try to lend you another. I am still of the opinion that the article contains the essence of what has been and is to be done, and that its perusal will not only facilitate the labors of your committee but enable present workers in the matter to avoid neglect and injustice toward their predecessors from Chaussier down."

§142. To my earlier inquiry (March 20, 1892), as to whether the Handbook article had reached him, Dr. Krause replied under date of April 12: "The [second?] copy of your mentioned article has been set in circulation among the members of the committee."

§143. The foregoing was my last communication from the secretary. A feature of the article of Prof. His ('95; see Part VI) led me to ask Dr. Krause (Dec., 1, 1895) whether the article had ever been transmitted to the former. To this query, which was repeated July 10, 1896, no reply has been received. See, however, the letter of Prof. His, Aug. 27, 1896; Part VI.

§144. On the fourth of April, 1892, Dr. Krause had sent me a list of the then members of the committee (eighteen in number), and suggested that copies of my papers be sent to them direct. So far as practicable that has been done ever since.

§145. The kind offer made in Dr. Krause's letter of April 15, 1891, was duly fulfilled. From time to time there reached me copies of most of the several "Abstimmungs" and "Schlussredactions", the last arriving early in 1894. They comprise nine hundred and forty-two large pages, and constitute a monument to the learning and industry of the secretary of the committee. Although not published in the ordinary sense, the large number of the committee, their wide European distribution, and the commentaries of Prof. His ('95), lead me to

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[1] Apparently this copy was lost in transmission; a second was obtained from a member of an American Committee and mailed with the above letter.

regard occasional reference to their contents as no breach of confidence.

§146. Besides the reprint in the "Monatschrift" as announced in his letter of April 15, 1891, Dr. Krause reproduced the "Preliminary Report" of the committee of the Association of American Anatomists (1889, §81) upon p. 104 of the "Osteologie, Abstimmung I," and upon p. 105 the Table of arterial names from my paper, '85,*g*. Upon p. 103 are comments, translated as follows:

> " In America also has been formed a committee upon Anatomical Nomenclature. Their proceedings have so far led to the herewith published preliminary recommendations. At the beginning of Osteology the proposal to apply *thoracic* instead of *dorsal* to a region of the vertebral column would be taken into consideration. Wilder further proposes to choose if possible [wo möglich] mononyms instead of polyonyms, i. e., to say, A. *praecerebellaris* instead of A. *cerebelli superior.* [This last sentence is most important]. In Wood's Reference Handbook of the Medical Sciences (VIII, p. 523) are discussed the advantages of mononyms (single word terms) over polyonyms. That such proposals cannot be practicable is evident from a glance at the appended list of arteries, or by recalling the binominal system of designation introduced by Linnaeus, which only made possible the development of descriptive Natural Science."

§147. Notwithstanding the fact that the implied accusation as to my accepting no terms consisting of more than one word is refuted by the dionym quoted, *A.* (*Arteria*) *praecerebellaris*, this self-raised specter of an exclusive dogma of mononymy so haunted the German committee that when their final Report was adopted, April 19, 1895, the Record of the Proceedings of the Anatomische Gesellschaft (*Anatomischer Anzeizer*, "Ergänzungsheft," 1895, p. 162) contains the following extraordinary manifesto (here translated):

> " On motion of the Nomenclature committee (signed by the members present at Basel, Herren von Kölliker, W. His, Leboucq, Toldt, Fr. Merkel, Schwalbe, Waldeyer, Romiti, von Bardeleben) the anatomical society makes the following declaration: The Anatomische Gesellschaft believes it should take a stand with regard to the endeavors of the American Nomenclature Committee. It acknowledges the usefulness of as short names as possible, and the suitableness of some propositions that have some from America. But it protests against the reckless [rücksichtlose] introduction of mononyms, and against the consequent radical remodelling of anatomical language as it has hither-

to existed. Consideration for the already established laws of common language formation, as also regard for the historic development of our own science, forbid the Anatomische Gesellschaft to follow the American committee in this way. Should the formation of a peculiar anatomic vocabulary in America advance in the direction indicated, there would then be opened an impassable gulf between the representatives of anatomic and medical science, and consequently the coöperation in scientific work hitherto existing would be deeply disturbed."

§148. In order to appreciate the full significance of the foregoing, there must be borne in mind certain facts: (*a*) It is directed by the Anatomische Gesellschaft against the endeavors [Bestrebungen] of *the* American Nomenclature Committee. (*b*) At that time (spring of 1895) there were *four* American committees (§§80-84) representing three distinct associations. (*c*) The committee of the Neurological Association had not then reported. (*d*) The reports of the other three committees were substantially embodied in that of the most comprehensive committee of the most comprehensive association, viz., the A. A. A. S., (§84), of which I was not a member. (*e*) What had been done by any American committee up to the spring of 1895, therefore, is represented by sections 1-5 of the Neurological report (§80). (*f*) The recommendations therein contained had been adopted *unanimously* by the three committees and by the three associations, hence the reference of the Anatomische Gesellschaft to *the* American Committee, while strictly inaccurate, really did no injustice.

§149. Having disposed of these historic details let us now see whether the real divergence between the American and German conclusions at that time was such as to warrant warnings and injunctions so solemn and sweeping as are contained in the declaration above quoted, (§147.)

§150. The American recommendations may be grouped as (*a*) specific and (*b*) general. The specific refer to the following terms: (1) *vertebrae thoracales;* (2) *hippocampus;* (3) *pons;* (4) *insula;* (5) *calcar;* (6) *pia;* (7) *dura.* Of these seven, four, a majority, coincide absolutely with the German adoptions.

§151. The other three are discussed in Part III, §§105, 116, 117). As there remarked, the German adoption of *fissura calcarina* (§108) and *cavum subdurale* (§118) practically concedes the adequacy of *calcar*, *dura* and *pia*.

§152. The special application of *dorsal* and *ventral* to the spinal cornua and nerve roots is involved in the general recommendation of the American committees to employ those explicit adjectives in place of the ambiguous toponyms of anthropotomy, (§132). As already stated (133) the maintenance of the latter by the Anatomische Gesellschaft contravened the opinion of the oldest German anatomist, who was also chairman of the "Nomenclatur Commission." Americans are not likely to repent of a step that has been sanctioned by such authority.

§153. There remains the general recommendation included in section 4, viz., "That, other things being equal, mononyms be preferred to polyonyms." So far as may be inferred from the official declarations of the Gesellschaft, and from the papers of its secretary and of Professor His, this constitutes the most substantial element of the terminologic phantasm which the Germans have erected between themselves and the American committees.

§154. How unsubstantial even this really is may be seen from the following facts: (*a*) Of the eleven specific terms adopted by three American committees up to the spring of 1895, five, nearly one half, were polyonyms, viz., *vertebra thoracalis*, *radix dorsalis*, *radix ventralis*, *cornu dorsale*, and *cornu ventrale*. (*b*) Even among the forty specific terms adopted by the Neurological Association in 1896 (§80) nine are polyonyms, nearly one-fourth of the whole. (*c*) Among the (about) five hundred and forty neural terms adopted by the Gesellschaft, at least forty, about one-fourteenth, are mononyms, and there are others among the names of the other parts of the body.

§155. In short, before condemning the American committees for prefering CALCAR to *calcar avis*, and PIA and DURA to *pia mater* and *dura mater*, the Germans must justify their recommendation of the following mononymic substantives in place of polyonyms all of which are perfectly legitimate, and some of which have been hithero more commonly employed: ATLAS (*vertebra cervicalis prima*); EPISTROPHEUS (*v. c. secundas*); MANDIBULA (*os maxillare inferius*); THALAMUS (*thalamus opticus*); CUNEUS (*lobulus cuneatus*); PRAECUNEUS (*lobulus quadrilaterus*); UNCUS (*gyrus uncinatus*); HIPPOCAMPUS (*hippocampus major*); PONS (*pons Varolii*); INSULA (*insula Reilii*).

§156. Likewise, even had any one of the committees sanctioned certain mononymic adjectives that have hitherto been employed only by individuals, before entering upon an *Index expurgatorius* such "harmless vocables" as ARTERIA POSTCEREBRALIS (for *A. cerebralis posterior*), GYRUS SUBFRONTALIS (for *G. frontalis inferior*), and FISSURA PRAESYLVIANA (for *Ramus anterior ascendens fissurae cerebri lateralis* [*Sylvii*]), they must account for the following instances upon their own list of the replacement of qualifying phrases in perfectly good and regular standing by adjectives consisting of a single word each: MUSCULUS EPICRANIUS (*occipito-frontalis*); MUSCULUS PLATYSMA (*M. platysma myoides*); SULCUS PRAECENTRALIS (*S. centralis anterior*); and FISSURA CALCARINA (*F. occipitalis horizontalis*).

§157. Notwithstanding, however, the above enumerated German examples of mononymy, it must be admitted that there still exist somewhat radical distinctions in principle between the committees of the two nations. Good words may be predicated of both; but so may "good works" be done sometimes by the "unjust" as well as by the "just." The real distinction lies not so much in specific deeds as in general preference.

§158. As early as 1891, the principles upon which the German committee proposed to base their revision of Anatomic Nomenclature were formulated and announced as follows (Krause, '91, *a*):

> "Die erwähnten Grundsätze sind nicht so zu verstehen, als ob sie etwa ausnahmefreien Naturgesetzen entsprechen sollten. Ihre Formulirung ist um so mehr als eine provisorische zu betrachten, als es sich hier nur um die Myologie handelt.
>
> 1. Jeder Körpertheil darf nur einen einzigen lateinischen Namen haben. Es geht nicht an, wie es manche Handbücher thun, sich mit einem *sive* zu helfen und die beiden Ausdrücke dann abwechselnd zu gebrauchen. Deutsche Benennungen, insofern sie nicht ohnehin

feststehen oder soweit sie überhaupt nöthig, bleiben der freien Auswahl eines Jeden überlassen.

2. Der Name soll ein kurzes sicheres Merkzeichen sein und weder eine Beschreibung noch eine speculative Betrachtung in sich einschliessen.

3. Kein Körpertheil soll einen unnöthig langen Namen führen.

4. Kein Körpertheil soll denselben Namen haben, den schon ein anderer führt, mit Ausnahme etwa des Falles, wenn es sich um Homologien handelt.

5. Die Namen sollen sprachlich und orthographisch richtig sein.

6. Die Benennungen nach Personen werden so viel als thunlich vermieden, namentlich wenn sie beträchtliche historische Unrichtigkeiten enthalten.

7. Im Ganzen will die Commission conservativ im weitesten Sinne verfahren."

§158. In the following translation the bracketed interpolations refer to definitions or commentaries in the present article.

"The principles here stated are not to be understood as if meant for laws of nature free from exception. Their formulation is all the more to be regarded as provisional, since muscles alone are here in question:

1. Each part of the body should have a single Latin name. One should not, as in many manuals, employ a *sive*, and then use both expressions alternately [pecilonymy, §34]. German designations [heteronyms, §43], in so far as they are not already established, or so far as they are really necessary, are left to the free choice of the individual.

2. The name should be a short definite expression (sicheres Merkzeichen) and indicate neither description nor speculative observation, [§51, from Owen].

3. No part shall have an unnecessarily long name [magniloquy, §40].

4. No part shall have the same name that already belongs to another, except in the case of homologues, [homonyms, §§23, 67].

5. The name shall be grammatically and orthographically correct.

6. Personal designations are to be avoided as much as possible, especially when they contain considerable historic errors; [eponyms, §33].

7. In general the commission intends to act conservatively in the widest sense of the word."

§159. In August of the same year Dr. Krause presented to the British Association for the Advancement of Science a brief statement of principles (Krause, *b*) and commentary there on. The essential parts are here reproduced.

"The state of things has every year become worse and worse; in Germany especially it has become almost insupportable [§§58-60] * * * In the same university sometimes different anatomical nomenclatures exist. * * * In two or three years we shall have finished and then we shall ask the anatomists of other countries to give their candid opinion on the whole. '

1. The name should be as short as possible.
2. Personal nomenclature should not if possible be used.
3. No part should have more than one name.
4. This name shall always be a Latin one; every nation can afterward easily translate it [§42] after its own fashion. Latin is the only real international language [§46], and by adopting it we hope to have a sound foundation."

§160. For the most part these principles are to be commended. Before suggesting qualifications of the fourth items I cannot refrain from calling attention to the absolute lack of intimation either that any of these principles had ever been enunciated before, or that any individual or committee had ever undertaken to effect an improvement in anatomic language. Granting the inutility of American precepts and examples that a German should present to an English scientific body propositions as to terminologic reformation as if they were wholly original and without (so far as recorded) naming those apostles, Barclay, Whewell, Owen, and Pye-Smith (the last still living), was surely most incongruous.

§161. It will be seen from the various passages above quoted that the Germans are at last[1] in accord with the Americans in recognizing the value of brevity as a feature of anatomic terms. But I have as yet failed to find in their publications or private letters even the faintest glimmer of comprehen-

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[1] I say *at last*, in view of the enormous number of lengthy terms, both Latin and vernacular, for whose continuance and even origin German anatomists are responsible; §60. Some of the heteronyms are indeed "fearfully and wonderfully made," and can be most fitly characterized as verbal "tandems," unmanageable by persons not specially trained. As remarked by Owen, "The happy facility for combination which the German language enjoys has long enabled the very eminent anatomists of that intellectual part of Europe to condense the definitions of anthropotomy into single words; but these combinations cannot become cosmopolitan; such terms as 'Zwischenkiemendeckelstück,' are likely to be restricted to the anatomists of the country where the vocal powers are trained from infancy to their utterance."

sion of the more fundamental grounds upon which the American committees prefer not merely that terms should be reasonably short, but also, when practicable, consist of single words each, i. e., mononyms, or, at most, of two words each, a noun and a mononymic adjective.

§162. In addition to the incidental previous references to the subject in the present paper (§§25, 47, 50) the differences between the more and the less essential advantages of mononyms over polyonyms may be fairly indicated by extracts from two earlier articles. The first ('84, *e*) was presented to the American Association for the Advancement of Science in connection with my suggestion that a committee on Anatomic Nomenclature be appointed by that body. Since it contains no reference to prior terminologists, it may be proper to add that, as published, it was a mere abstract, and that in both earlier and later papers of greater length ('81, *b*, *c*; W. & G., '82, '89), an effort was made to give due credit to those who had either indicated or smoothed the way.

§163. "7. Should not organonymic terms (terms of designation) be, as far as practicable, brief; capable of inflection; classic in derivation and form; already used in a kindred sense? [1]

8. Since the length of a term may depend upon not only the number of syllables and letters, but also upon the number of separate words, and since, properly, only single words are capable of inflection, is there not a twofold reason why the names of parts, *with certain self-evident exceptions*, (*nerves, etc.*[2]) should be mononymic?

9. Is there much real analogy between the nomenclature of anatomy and that of zoology and botany? [cf. §146, last line.]

10. How far should priority be regarded in the selection of existing names?

11. Can priority be claimed for terms which are vernacular or descriptive?

12. In considering all questions of terminologic reform, should we not regard less our present and personal convenience, than the interests of the vastly more numerous anatomical workers of the future?"

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[1] [This note was a part of the paper.] "In later papers ('85, *b* and *c*) I have suggested that, in English works, so far as possible, the names be given an English aspect by paronymization. For example, *commissura* becomes *commissure; pedunculus, peduncle.* With many names no change is needed, as with *porta*, *aulix*, *fornix*, *callosum*, etc. Heteronyms or vernacular translations are regarded as objectionable. The same principle is applicable to other languages."

[2] This phrase is italicized for a reason that will appear later, §172.

§164. The distinctions were more fully set forth seven years ago in the later article (W. & G., '89, 523) from which is taken the following summary.

A. From mononyms adjectives may be regularly derived.

B. Mononyms are more readily compounded.

C. Mononyms are constant in form, excepting for the regular derivatives, numbers, cases, adjectives, and paronyms.

D. Polyonyms, on the contrary, are subject to variations of several kinds: (*a*) By omission of words. (*b*) By the conversion of genitives into adjectives. (*c*) By the substitution of totally different words. (*d*) By permutation (§37).

E. Mononyms may be more uniformly abbreviated (§38).

F. Mononyms are commonly shorter than the corresponding polyonyms. The exceptions are due to the fact that the absolute length of a term depends upon three factors, viz, (*a*) the number of words; (*b*) the number of syllables in the words; (*c*) the number of letters in the syllables. The written length of a term is affected by all three of the above named conditions; but its spoken length is independent of the number of letters.

§165. But the essential characteristic and principal advantage of the Latin mononym is (G) that *it is capable of adoption into any other language, either unchanged, or with so slight a modification as not to hinder its ready recognition by the anatomist of any nationality.*

§166. Between longer and shorter words is merely a difference in *degree*, e. g., *crus* and *pedunculus*; between a Latin word and its vernacular equivalent or heteronym (e. g., *pedunculus* and *footlet*) and its paronym (*peduncle*) the choice might depend upon individual preference; but mononyms and polyonyms, terms of one word each and terms of two or more (e. g., *pedunculus* and *pedunculus cerebelli*) differ in *kind*; it is not a question of size or euphony, but of essential endowment and capacity. The mononym is to the polyonym as is the water to the earth or as is the bird to the tortoise.

§167. The desirability of replacing polyonyms by mononyms is in direct ratio with the frequency with which the part is mentioned, and with the need of employing corresponding adjectives. *Hypophysis* (formerly pituitary body) and *conarium* (formerly pineal gland) are much more frequently named since the discovery that the former has peculiar developmental relations with the pharynx, and the latter even more remarkable connection with a vestigial organ of sight. So long as the thin sheet of nervous tissue just dorsad of the chiasma was regarded as insignificant, and even as occasionally absent, either *lamina cinerea* or *lamina terminalis* might not be so objectionable; but its now-admitted morphologic importance as the cephalic boundary of the encephalic cavities justifies the use of the mononym, *terma*. The orifice left by the removal of the hypophysis and infundibulum had apparently received no name up to 1880; *foramen infundibuli* was a sufficiently appropriate descriptive term; but the frequency of its mention in notes respecting the preservation of the brain led me to discard it in favor of *lura*. The first two cervical vertebrae alone have mononymic titles; but were there similar anatomical, physiological, or surgical occasions for specifying any other member of the vertebral series, a mononym would probably soon be proposed and generally accepted.

§168. The German criticisms of the American methods and results quoted above (§§147-153) are comparatively brief and general. A more extended and particular arraignment is contained in the article of Prof. Wilhelm His ('95, 6-7). Although published under his name, yet its association with the official list of *Nomina anatomica*[1] as adopted by the Gesellschaft, the prominent part taken by him in the formation and work of the committee, and his high reputation based upon splendid contributions to science extending through many years, all endow his utterances upon the subject with not merely personal but semi-official significance. Indeed, in the absence (so far as I know) of any dissent therefrom, those utterances must be regarded as representing the views of the older German anatomists[2]. On this account it is more to be regretted that some of his criticisms should exhibit in a marked degree the lack of information and of comprehension mentioned in the introduction to the present article (§§3-4).

§169. Criticism by Prof. Wilhelm His ('95, 6-7).[3]

"Die anatomische Gesellschaft Grossbritanniens hat 1893 eine eigene Commission zur Anpassung unserer Vorschläge an die englischen Bedürfnisse niedergesezt,[4] und etwas früher noch (1890) hat eine Gesellschaft amerikanischer Anatomen die Nomenclaturfrage in die Hand zu nehmen versucht. Die Aeusserungen der englischen Commission liegen noch nicht vor, dagegen haben die amerikanische Commission und deren sehr eifriges Mitglied, Hr. Wilder, bereits

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[1] It would be desirable to know whether the list may be obtained otherwise than as part of the article, as will be the case with Part VII of the present paper.

[2] By some of the younger neurologists the American ideas have been more hospitably entertained and certain newer terms actually adopted.

[3] The original is here reproduced *verbatim et literatim et punctuatim.* In the translation (§170) I have ventured to modify certain subordinate features that may have been due to haste upon the part of the author or proof-reader.

[4] *Journal of Anatomy and Physiology*, 1894. Vol. XXVII [XXVIII].

eine Reihe von kleineren Aufsätzen und Broschüren veröffentlicht[1]

"Die Ziele, welche die amerikanische Commission verfolgt, sind dieselben wie die unsrigen, ihre Wege zum Ziel sind aber wesentlich andere, als die von uns gewählten. Gemeinsam ist uns der Grundsatz, dass jeder Theil nur einen einzigen Namen haben soll, und dass dieser Name möglichst einfach und bezeichnend zu wählen sei. Wilder und seine Collegen gehen aber weiter und verlangen lauter "Mononyme," d. h. Substantive ohne ferneren Zusatz. Sie sagen z. B.: praecornu und postcornu satt cornu anterius und cornu posterius, postcava statt vena cava posterior u. a. m. Bis jetzt liegt von Wilder die Bearbeitung der Gehirnnomenclatur nach den vorgeschlagenen Grundsätzen vor, und dieser erste Versuch erlaubt uns ein Urtheil über die Consequenzen, zu welchen das vorwiegende Bestreben nach Mononymen hinführt. Wir stimmen unsererseits völlig bei, wenn das wort Thalamus kurzweg an die Stelle von Thalamus opticus gesetzt wird, wir haben selbst nichts dagegen, wenn im täglichen Verkehr das Wort Dura für dura Mater encephali in allen den Fällen gebraucht wird, wo eine Verwechselung ausgeschlossen bleibt. Dagegen können wir nicht anerkennen, dass Worte wie "Medipedunculus" für Pedunculus cerebelli ad pontem einen sprachlichen oder praktischen Fortschritt bedeuten. Die Zusammenziehung verschiedener Worte in ein einziges kann ja unter Umständen eine Vereinfachung sein. Aehnlich dem allzu gedrungenen Telegraphenstil kann sie indessen auch zur Unklarheit führen, und dann ist ihr Nutzen ein negativer, denn also gebildete Worte verlangen zu ihrem Verständniss besondere Erläuterungen. Medipedunculus ohne Zusatz ist unverständlich, es müsste schon Medipedunculus cerebelli heissen, und dem wäre wiederum Pedunculus medius cerebelli vorzuziehen, weil das barbarisch gebildete Wort Medipedunculus ebensowohl für Pedunculus medius, als für Pedunculus medialis oder für Pars media oder medialis pedunculi gebraucht werden könnte. Sprachwidrige Wortzusammensetzung enthält aber Wilder's Liste sehr viele, und man hat nicht nöthig, ein philologischer Pedant zu sein, um in Worten wie Terma (anstatt Lamina terminalis), Postramus (für Ramus posterior arboris cerebelli) u. a. m. Aergerniss zu nehmen. Viele Worte, wie Cimbia (Tractus peduncularis transversus), coelia (für Cavitas encephali), Aulix (für Sulcus Monroi) u. a. m. sind übrigens neu oder wie Isthmus (für Gyrus annectens) in einem anderen, als dem bisherigen Sinn benutzt. Ich weiss nicht, wie weit der Kreis amerikanischer Fachgenossen reicht, welchen Wilder hinter sich hat. Jedenfalls führt das

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[1] Von den durch Wilder versandten Schriften citire ich als die hauptsächlichsten. The fundamental principles of anatomical Nomenclature, by Burt C. Wilder MD. from the *Medical News.* 19. December 1891.

Ferner: Fissural diagrams of the human brain. *Macroscopical Vocabulary of the brain presented to the Assoc. of American anatomists at Boston, Mass.* 29. Dec. 1890. American Reports upon Anatomical Nomenclature. 1889-1890, with Notes by Wilder, Cornell University, 5. February 1892.

Vorgehen des letzteren zur Schaffung einer völlig neuen, grossentheils recht fremdartig klingenden Sprache, und auf diesen Boden kann ihm unsere Commission, ohne Verleugnung ihrer historischen Grundsätze, nicht folgen."

§170. In the following translation of the foregoing extract from the article of Prof. His ('95, 6, 7), besides corrections of supposed typographic errors, and changes in the order of words in accordance with more usual English custom, there are introduced in brackets (*a*) words from the original that might have more than one meaning; (*b*) references to sections of the present article; (*c*) letters to facilitate the assignment of subsequent commentaries to the special points involved.

"The anatomical society of Great Britain appointed in 1893 its own commission to adapt our propositions to English needs,[1] and somewhat earlier still (1890), [*a*] a society of American anatomists [*b*] tried to take up the nomenclature question. The statement of the English committee is not at hand, but the American committee [*c*] and its very ardent member, Mr. Wilder [*d*], have already published a series of small papers and *brochures*.[2] The aims of the American committee are the same as our own, but their methods are essentially [*f*] different from those chosen by us. The fundamental idea is the same, that each part should have only a single [Latin] name (§46), and this the most simple possible [*g*]. But Wilder and his colleagues [*h*] go farther and desire [*i*] absolute [*verlangen lauter*] mononyms, *i. e.*, substantives without further additions. They say [*j*], for example, *praecornu* and *postcornu* instead of *cornu anterius* and *cornu posterius*; *postcava* [*k*] instead of *vena cava posterior*, with many similar terms. We have already the treatment of encephalic nomenclature by Wilder in accordance with the proposed method, and this first attempt allows us [*l*] to form an opinion as to the results [*m*] to which the preponderating [*vorwiegende*] effort toward mononymy leads. On our part we assent fully when the word *thalamus* alone [*n*] takes the place of *thalamus opticus*; we even do not object if, in ordinary communications,

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[1] *Journal of Anatomy and Physiology*, XXVIII [not XXVII, as in original], pp. VII-IX, 1894.

[2] I cite here the chief [*hauptsächlichsten*] of Wilder's [*e*] transmitted [*versandten*] publications: "The fundamental principles of Anatomical Nomenclature," The *Medical News*, Dec. 19, 1891, 708-710. "Fissural Diagrams," accompanying "Remarks on the Brain of Chauncey Wright, with Commentaries upon Fissural Diagrams," *Jour. of Nervous and Mental Disease*, XVII, 1890, 753-754; *Amer. Neurolog. Assoc. Transactions*, 1890. "Macroscopic Vocabulary of the Brain, with Synonyms and References;" presented to the Association of American Anatomists, Dec. 29, 1890; O., pp. 13. "American Reports upon Anatomical Nomenclature, 1889-1890, with Notes." O., pp. 3, Feb. 5, 1892.

[*o*] the word *dura* for *dura mater encephali* is used when misapprehension is impossible. But we cannot acknowledge that words like *medipedunculus* [*p*] for *pedunculus cerebelli ad pontem* constitute a linguistic or practical improvement. The contraction of several words into a single one may be under certain circumstances [*q*] a simplification; but, as with the too concise telegraph style [*r*], it may, on the other hand, involve lack of clearness, and then its advantage is negatived; for words formed in this manner demand a special explanation for their comprehension. *Medipedunculus* alone is unintelligible [*s*]. It must surely be called *medipedunculus cerebelli*, and over this again should preference be given to *pedunculus medius cerebelli*, because the barbarously formed [*t*] word *medipedunculus* could be used indifferently for *pedunculus medius*, for *pedunculus medialis*, or for *pars media* or *medialis pedunculi* [*u*]. But Wilder's list contains very many [*v*] ungrammatic verbal combinations, and one need not be a philologic pedant [*w*] to take offense at words like *terma* (instead of *lamina terminalis*) [*x*], *postramus* (for *ramus posterior arboris cerebelli*) [*y*] and others. Many words like *cimbia* (for *tractus peduncularis transversus*) [*z*], *coelia* (for *cavitas encephali*) [*α*], *aulix* (for *sulcus Monroi*) [*β*], and others, are moreover new [*γ*], or, like *isthmus* (for *gyrus annectens*), used in another than the accepted sense. I know not how far may extend the circle of American collaborators supporting Wilder [*δ*]. At all events, his proposals tend to create a language entirely new [*ε*] and for the most part quite strange, and on this ground our commission cannot follow him, without renouncing its historic principles [*η*]."

§171. Certain points in the foregoing extract have already become the subjects of the correspondence between Prof. His and myself referred to in the Introduction (§4) and constituting Part VI. Their inclusion in that later division of the present article is the more desirable in view of the hope based upon my last letter from Prof. His that, before that part is put in type, he may have discussed those points publicly.

§172. It will be seen that, like the German committee and the entire Gesellschaft, Prof. His is disturbed by the American preference for mononyms. In one passage he characterizes it as the "vorwiegende Bestreben" [m]; in another [i] by "verlangen lauter." Now *verlangen* has two distinct meanings, viz., *desire* or *prefer*, and *demand* or *insist upon*. As will appear in Part VI, it is now (Nov. 10, 1896) nearly a year since Prof. His had an opportunity to state in which of these senses the word is to be understood, and more than two months have elapsed since the ambiguity was brought expressly to his notice. The sweeping charge (§147) framed by the Gesellschaft in his presence and apparently under his direction would justify the interpretation of *verlangen* as *demand.* But until assured to that effect by Prof. His himself, I hesitate to entertain so monstrous a perversion of the facts upon the following grounds: (*a*) In all the reports of the American committees the expression of preference for mononyms is accompanied by the proviso "other things being equal." (*b*) I have repeatedly conceded the impossibility of the application of the principle to groups of parts, fissures, gyres, vertebrae, bloodvessels, muscles and nerves. The remark that there are "certain self-evident exceptions (nerves, etc.)," occurs in a paper ('84, *c*; §163, 8) presented by me twelve years ago to the American Association for the Advancement of Science and printed in the *Proceedings* of that body (pp. 528-529). If Prof. His ever consults any American scientific publication it would seem not unnatural that the title of that paper, "On some Questions in Anatomical Nomenclature," should have attracted the notice of one who, three years later, himself urged ('95, 1) upon the German anatomical society the need of action upon the subject, and who was occupied therewith more or less for eight years afterward.

§173. In order to eliminate so far as possible the personal element from the consideration of the special criticisms of Prof. His, I select as the first subject of rejoinder a term, *postcava,* in which my interest is only indirect, as of one toward a child by adoption rather than by paternity. Omitting intervening phrases not affecting the interpretation, the complaint of Prof. His reads (translated) as follows:—"Wilder and his colleagues [*h*] * * * say [*j*] *praecornu* and *postcornu* for *cornu anterius* and *cornu posterius, postcava* [*k*] for *vena cava posterior,* with many similar terms." The implied disclaimer as to "philologic pedantry" [*w*] can hardly embrace a toleration of misstatement; hence, before discussing the intrinsic merits of the word selected, it may be well to dispose of minor points that might complicate the main issue.

§174. In the text Prof. His refers only to "Wilder," and in note 2 (see the original, §169) an initial is wrong. Hence it is only just to state that my terminologic transgressions must not be imputed to Harris H. Wilder, professor in Smith College, Northampton, Mass., whose researches, especially upon lungless salamanders,[1] make me proud to claim him as a distant relative.

§175. The objectionable words are attributed to "Wilder and his colleagues." Not one of the three specified words, or of the "many similar terms," has been sanctioned by either of the four committees, and few of the members thereof have adopted them. For the confusion and possible injustice here occasioned no adequate explanation can be offered.

§176. The phrase "postcava statt vena cava posterior" would naturally imply that the latter is the name preferred by the German committee. Yet the official list contains (p. 77) only *vena cava inferior.*[2]

§177. So far as appears in the article of Prof. His, *postcava* was coined by me. On the contrary, so far as I am aware, it (in the derivative, *postcaval*) was first introduced by Richard Owen about the middle of the century, and employed by him consistently thereafter.

§178. Whether or not the two historic facts just mentioned[3] were known to Prof. His he alone can tell, and the fate of other queries does not encourage an effort to ascertain. Hence I am compelled to offer propositions which each reader must accept, or reject, or explain in accordance with his own information and judgment.

(1). *Postcava,* in the form *postcaval* (§177), occurs frequently in the writings of a leading English anatomist.

(2). Those writings must be known and accessible to Prof. His. Hence there is no excuse for the erroneous intimation in the article.

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[1] *Anatomischer Anzeiger*, IX, Jan. 20, 1894, and XII, 182-192, 1896.

[2] In passing it may be remarked that the retention of *superior* and *inferior* as the essential elements of the designations of these great vessels constitutes one of the many evidences of the non-emancipation of the German committee from anthropotomic enslavement; see §133.

[3] My non-responsibility is certain; the responsibility of Owen is assumed in the absence of evidence to the contrary.

(3). Whatever its source, *postcava* differs from the more usual terms in its comparative brevity, while at the same time not open to the charge of ambiguity. Why then was it not included in the column of synonyms from "sonstigen Autoren" in the protocols of the German committee, as was a less common and acceptable synonym, viz., "vena cava inferior thoracica?"

(4). If the entire committee supposed me to be the author of *postcava*, their action was consistent, since no term is credited to me in the column indicated.

(5). But if any members of the committee knew that *postcava* originated with Richard Owen, their objections to the word might well have been waived out of respect for him.

§178. The actual form employed by Owen is specified above, not merely for the sake of accuracy, but also in order to forestall criticism upon a point where disagreement is possible. It is, I think, a sound proposition that *the introduction of any derivative, oblique case, or national paronym, practically renders the introducer responsible for the actual or potential Latin antecedent of such words, in accordance with the usual rules of derivation and paronymy.* I do not remember seeing the foregoing proposition distinctly formulated,[1] but reflection will show its soundness. One of the wisest recommendations of the A. A. A. S. Committee on Biological Nomenclature (§85) was that the Latin (international) form of a term should always be given, whether or not the national paronyms. Now *cava* is the feminine form of *cavus*, and *vena cava* was used (perhaps not in the specific modern sense) by Cicero, "De Natura Deorum," 2, 55, 38.[2] There seems to have been no classic adjective, although *cavatus*, the participle of *cavo*, was available as such. Analogy fully warrants (§116, et seq.) the acceptance of *cava* as a substantive, and the derivation therefrom of a secondary adjective in the form of either *cavatus* or *cavalis*. The latter evidently was

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[1] It probably has been in purely linguistic connections.

[2] For some discussion of *cava* see Hyrtl, '80, 98, 99.

chosen (constructively) by Owen when (in 1862, "On the Aye-Aye," *Zool. Trans.*, V, 86, and perhaps earlier) he employed *post-caval vein* and *pre-caval vein.* Later, the hyphen was omitted, and in the "Comparative Anatomy of Vertebrates" occur "postcaval vein, postcaval trunk, postcaval orifice, and postcaval," I, 503-505; II, 203; III, 552 et seq. Pending the discovery in Owen's writings of some history of the stages by which the final reduction was effected, the following series is certainly thinkable:—(1) Vena cava posterior; (2) Posterior vena cava; (3) Posterior caval vein; (4) Post. caval vein; (5) Post-caval vein; (6) Postcaval vein; (7) Postcaval; (8) Postcava. Whatever may have been the actual steps, never did Owen reach a more final terminologic result, and no case better exemplifies the unwisdom of the reactionary attitude of the German committee.

§179. Since Professor His offers no specific objections to *postcava* their nature can only be inferred from his general remarks and from his criticisms of *medipedunculus.* Perhaps therefore the simplest and most comprehensive rejoinder is to recapitulate briefly the several attributes of the term, leaving each reader to estimate their value for himself. Besides references to this article, the initial *G* will indicate terms adopted by the Anatomische Gesellschaft, or attributes commended by that body.

(*a*) Brevity; §§40, 50; G., §158, 3. (*b*) Latin form; §50; G., §158, 1. (*c*) It is a mononym; §§15, 47. (*d*) It is a locative name; §27. (*e*) It is an adjectival locative; §29. (*f*) It is capable of inflection, i.e., *postcavalis, postcaval, postcavals.* (*g*) Its various national representatives (paronyms §§43-45) differ little or none from the international antecedent. (*h*) It has in the derivative, *poslcaval,* high authority (Richard Owen) and moderate antiquity (1862 or earlier). (*i*) It is an idionym (§24) and not likely to be applied to any other part in any vertebrate. (*k*) It is sufficiently euphonious, and easily remembered. (*l*) Like other euphonious and easily remembered mononyms it constitutes no bar to the progress of one who may never have heard the more common polyonyms. Those who are familiar with those polyonyms, whether *vena cava inferior*, *vena cava ascendens*, or *vena cava posterior*, could hardly fail to recognize its signification. Since 1881 no other term than *postcava* has been used by me for the great vein in question. I have yet to learn of a single instance of misapprehension or other difficulty caused thereby among either general or special students.

§180. There remains the question of the etymologic orthodoxy of *postcava*, and this involves the much more comprehensive and difficult question as to the definition of etymologic orthodoxy. Without presuming to invade the jurisdiction of philologic experts, for the practical discussion of the case in point, precedents need be sought in only two periods, the classic and the recent.

§181. I freely admit that there is known to me no instance in classic Latin literature of the employment of *post*, whether alone or in composition, with the force of an adjective and as equivalent to *posterus* or *posterior*. That this negative evidence is hardly conclusive may be seen from a single case among the scores that might be adduced. With the Romans *item* was an adverb. With us it is not only an adverb, but also a noun and a verb, and the basis of two derivatives, *itemize* and *itemizer*.

§182. In recent times the precedents are partly direct and partly indirect. Among the former are *postabdomen*, *postact*, *postarytenoid*, *postfactor*, *postfurca*, *postpubis*, *postscapula*. In all of these *post* has the force of an adjective, not of a preposition.

§183. Indirect precedents are cases in which other prepositions have the force of adjectives in composition. Such are *preadaptation*, *precentor*, *preexistence*, *preformation*, *presternum*; also *subgenus*, *subflavor*, *subfactor*, *submaster*, *subtitle*.[1]

§184. Since, however, the German committee sanction none of the anatomic terms in the foregoing lists and avoid the

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[1] Among analogous Greek words the following has been furnished me by my friend, L. L. Forman, Instructor in Greek at Cornell University: *προφύλαξ*, an advance guard.

use of *praesternum* by retaining *manubrium sterni*, they would probably decline to regard them as adequate justifications for *postcava*. But can they consistently condemn it or any similar terms? Let us see.

§185. Prof. His, the German committee, and the Anatomische Gesellschaft, after several years deliberation and apparently without any disagreement, have adopted and recommended the names *metencephalon* and *prosencephalon* for certain segments of the brain. Now *meta* and *pros* are the English forms of the Greek μετά and πρός. These are both prepositions. Like *post* and *prae* they are also adverbs. The terms into which they enter have no reference to a third part "behind" which or "before" which the metencephal and prosencephal are situated. The German translation of *prosencephalon* is *Vorderhirn*, and the English, *forebrain*, both signifying the first or most cephalic member of the series of coördinate encephalic segments. With slight modifications the foregoing remarks apply equally to a third name adopted by the German committee, *diencephalon*, the preposition διά having the force of an adjective.

§186. I am unable to recognize any distinction, logical or etymological, between the *metencephalon* and *prosencephalon* which the Germans commend, and the *postcava* and *praecava* which Prof. His condemns. The irregular terms for which he is in part responsible may be few; but his virtuous denunciation of me for producing a larger number of the same sort is no more reasonable than the demand of the woman to be punished lightly for bringing forth an illegitimate child upon the ground that it was "such a little one."

§187. Strictly, however, even if the degree of opprobrium to be cast upon the individual concerned were to be measured by the number of terms of a certain kind, this would have no bearing upon the question of the acceptability of a given term. *Postcava* and *praecava* are to be considered upon their merits as brief, convenient, and absolutely unambiguous designations intended to replace inconvenient descriptive phrases. In favor of *vena cava superior* and *vena cava inferior* antiquity alone can be urged; against *praecava* and *postcava* can be alleged only the sinfulness of comparative youth.

§188. In the foregoing discussion I have refrained from following one line of argument that readily suggests itself and is, indeed, almost formulated in the hypothetic series between *posterior vena cava* and *postcava* as stated in §178, *viz.*, The prefix *post* might not unnaturally be regarded as the abbreviation of *posterior* or *postero.* Were compounds of *post* alone concerned, this simple line of argument might perhaps be adequate; but it will not serve for compounds of the correlative *prae*, nor for those of the Greek prepositions, ἐπί, μετά, ὑπό, etc.

§189. The straightforward way of dealing with the matter is to assume that *post* and *prae*, in composition, may have the force of the adjectives *posterior* and *anterior* respectively.[1] "If this be treason, make the most of it."

§190. It seems to me that the nature of the issue between *postcava* and *vena cava inferior* (or *posterior*) is such as to involve the acceptance or rejection of the following propositions.

A. Language was made by and for man, and not the reverse.

B. Grammatic rules are framed from time to time in order to maintain the uniformity that is acceptable and convenient.

C. Like the roads we traverse, such rules are but means to ends, and have no intrinsic sanctity.

D. Like a circuitous but familiar road, a commonly accepted rule is not to be abandoned without reflection. On the other hand, no more is it to be laboriously travelled when new conditions render a "short cut" desirable.

E. Extrinsic toponyms (*i. e.*, terms of location or direction that do not refer expressly to the recognized body-regions, dorsum, venter, etc.) should conform to the more usual vertebrate attitude rather than to the erect attitude of man; *e. g.*,

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[1] It is well understood in this country that the *New York Medical Journal* and the "Encyclopaedic Medical Dictionary" stand for the highest scholarship. Yet so long ago as 1885, when some of my simplified terms were submitted to him, their editor, Dr. F. P. Foster replied, "I think some of the words excellent, *praecommissura*, for example."

posterior and *anterior*, *superior* and *inferior*, and their derivatives, compounds, and abbreviations, should have significations zoötomic rather than anthropotomic.

F. There now prevail and are likely to persist two conditions not merely unknown to the *Patres anatomici*, but probably not imagined by them: (*a*) the enormous increase of anatomic and physiologic knowledge; (*b*) its general diffusion among the people.[1] These two conditions[2] militate against the rigid maintenance of grammatic rules that might prevent the establishment of new and shorter channels, or the fabrication of new and briefer technical terms, the "tools of thought." Terms like *vena cava posterior* are obtrusively Latin, and hence not acceptable to the laity; too much time and space are lost in speaking and writing them, and time and space are daily becoming more precious.

§191. Consciously or unconsciously, for many years English and American anatomists have been gradually simplifying their terminology in substantial accordance with the foregoing propositions. In Germany the signs of such improvements are as yet comparatively few.

§192. Even if, however, the German committee were reconciled to the employment of certain prepositions in composition with the force of adjectives, there would still remain[3] special objection to *post* as indicating toward the tail rather than toward the back. This objection is radical, and the conflict involved is irrepressible; §§131-133.

§193. *Postramus.*—To this, as a mononymic substitute for *Ramus posterior arboris vitae cerebelli*, Prof. His offers no

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[1] In fulfilment of the declaration of the elder Agassiz, "Science must cease to be the property of the few; it must be woven into the common life of the world."

[2] There is really a third condition, equally novel, but bearing less directly upon the present question, viz., the pursuit of anatomy by women. Whatever view may be taken of this in other respects, all decent men must rejoice that it has hastened the elimination of the needless *Nomina impudica* which formerly defiled even the description of the brain. For further commentary upon this matter see W. & G., '82, 27.

[3] Excepting with the chairman, §133.

specific objections (§170, *y*) but they may be inferred to be (*a*) that it is a *post* compound (§§174-191); (*b*) that the German list does not include any terms for the branch-like divisions of the cerebellar "tree." If these branches no longer merit specification, *postramus* and *praeramus* will vanish quietly with the polyonyms from which they were condensed.

§194. *Terma.*—From the context (§170, *x*) it may be inferred that this is objected to upon etymologic grounds. *Terma* does not, it is true, occur in classic Latin lexicons. But neither does *chiasma* which is embraced within the German list. The latter is the "new Latin" paronym of χίασμα, and *terma* is merely somewhat newer Latin for τέρμα. Why should we use the longer Latin *terminus* for *terma* any more than the longer Latin *decussatio* for *chiasma*?

§195. *Aulix.*—This (§170, *β*) is the regular Latin paronym of αὔλαξ and signifies a furrow. It was proposed by me as a mononym for Reichert's *Sulcus Monroi*, not merely as a mononym but because its resemblance to *aula*[1] readily recalls the fact that it connects the lateral orifice of the aula (the porta) across the face of the thalamus with the funnel-shaped orifice of the "aqueduct." If, as apparently held by His and Minot, this furrow should prove to be only part of the general boundary line (*Sulcus limitans ventriculorum* or *Sulcus interzonalis*) between the dorsal and ventral zones, then it might not need specification. But the later observations of Mrs. Gage ('96, *a*), as stated in my paper ('96, *d*), cast considerable doubt upon this interpretation of the "sulcus Monroi." In any case it must be borne in mind that it extends from the aqueduct to the aula and not to the *Recessus opticus* as represented in one published figure.

§196. *Cimbia.*—This architectural term, signifying a band, fillet or cincture, was used by me in 1881 in discussing the very distinct ridge across the crus (cerebri) of the cat before I knew that it had been called *Tractus peduncularis transversus* by Gudden (1880) and still earlier (1861) *fascio transverso* by an Italian

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[1] My mononym for *pars ventriculi communis media*, pars *foraminis Monroi media*, etc.; §211.

anatomist. Unless the first name is to be retained there can be no logical objection to replacing the second by a third. The most complete exemplification of the practical superiority of *cimbia* is supplied by the section concerning it in the latest edition of the "Gewebelehre" by the distinguished chairman of the German committee. On pp. 606–609 (really only three pages if the cuts be excluded) and in addition to the page-head and the section-title, *Tractus peduncularis transversus* occurs ten times, occupying more than five full lines. The occurrence of *Tractus peduncularis* in one place, and of *Tractus* alone or in composition with German words in several, shows how burdensome the polyonym had become, and how irresistible the temptation to vary. In the explanation of Fig. 707, the full title occurs once; also *Tract. ped* and *Tr. ped.*; compare §38. *Tractus transversus pedunculi* of Brissaud is declared to stand for a different bundle, but in the absence of such declaration the two names would almost inevitably be supposed to mean the same thing anatomically as they do etymologically. Again, since Kölliker concedes pedunculi also to the cerebellum (pp. 337, 371, etc.), and since many anatomists prefer to designate the fibrous masses between the pons and the optic tracts as the *crura*, there is ample opportunity for misapprehension upon the part of the student, unless, in accordance with the absolute explicitness insisted upon by His (§ 170, *s*), there be introduced the qualifier *cerebri* or *cerebralis*. All these objectionable conditions vanish with the adoption of *cimbia*.[1] Even if this were rejected, ambiguity could be avoided and brevity attained by designating the great fibrous masses above mentioned as crura rather than pedunculi, thus providing for *Tractus cruris transversus*, as suggested in W. and G., '89, §57, note.

§197.—*Isthmus.*—Prof. His complains that this word is used by me in the sense of *Gyrus annectens*. This latter term does not occur in the German list, so I assume that *Gyrus transitivus* is meant. No one of my terminologic propositions gives

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[1] That it is not classic Latin, and that it may even have been a corruption of *cimbra*, constitute no bar to its adoption into anatomy.

me more satisfaction than that of replacing *Gyrus annectens*, *bridging convolution*, and *pli de passage*, by *isthmus* when the cortical area is visible at the surface, and by *vadum* when it is concealed; the occasional interruption of the central fissure is thus the *Isthmus centralis;* that between the adjoining ends of the parietal and paroccipital fissures, the *Isthmus paroccipitalis*, etc. So far I cheerfully plead guilty to the charge. But with what justice does Prof. His complain further that this employment of *isthmus* is in an "unusual sense" when his own list contains *Isthmus gyri fornicati*? Indeed, even were this complaint well-founded, it comes with a poor grace from (*a*) a German whose fellow-countryman (Waldeyer) applied (1891) to the nerve-cell the term *neuron*, which had been introduced by me ('84) for the entire cerebro-spinal axis; from (*b*) a member of the Nomenclatur Commission whose chairman (Kölliker) applied (1893) to the axis-cylinder process of a nerve-cell a term (*neuraxon*) practically identical with one (*neuraxis*) which occurs in a standard French Medical Dictionary for the cerebro-spinal axis; and from (*c*) one who himself, upon altogether inadequate grounds, has made the term in question, *isthmus*, of segmental value, and who has needlessly and unjustifiably modified the scope of *prosencephalon* and reversed the hitherto commonly accepted sense of *metencephalon*; see Table VII.

§198. *Medipedunculus.*—To this term Prof. His devotes one-fourth of his entire criticism (§170, *p-u*). Hence some rejoinder should be made although the objections impress me as either ill-founded in themselves or inconsistent upon the part of the objector. As a word, *medipedunculus* is no more "barbarous" than *meditullium*, *Mediterranean*, or *medieval*. As a designation rather than a description, it requires definition. The beginner would remember *medipedunculus* quite as easily as "pedunculus cerebelli ad pontem";[1] and since experienced anatomists know that there are three cerebellar "stalks" on each side but only two "pedunculi cerebri," one on each side,

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[1] This term, by the way, does not occur in the German list, where apparently it is replaced by brachium pontis.

he is not likely to infer that either of the latter is meant by *medipedunculus.* In fact, this term, as coined and defined by me,[1] is now an idionym, applicable to but a single part of the brain.

§199. In order to be absolutely explicit and independent of the context the following terms from the German list should be accompanied by the words here bracketed after them:—*Clivus* [*occipitalis*]; *Clivus* [*sphenoidalis*]; *Pars cervicalis* [*medullae spinalis*]; *Sulcus lateralis anterior* [*medullae oblongatae*]; *Sulcus limitans ventriculorum* [*encephali*]; *Pars centralis* [*ventriculi lateralis*]; *Ventriculus terminalis* [*medullae spinalis*]; *Lamina terminalis* [*encephali*]. The identity of the adjective in the last two terms would lead the beginner to associate them topographically, and he certainly would never infer that they designate parts at opposite poles of the cerebro-spinal axis.[2]

§200. From the standpoint of Prof. His the foregoing must be regarded as serious blemishes upon the German list. From my point of view, although I might object to certain of the names as such, it would not be on account of their lack of explicitness. As has been said above (§26) in many instances explicitness is to be gained from the context. But with really the larger number, I am confident that well selected, brief, and fairly suggestive designatory names can and will be learned and remembered without any difficulty, especially if the study of the brain be begun at an early age; see Part VIII.

§201. *Coelia.*—This word, in place of *cavitas encephali s. ventriculus encephali,* is one of the three cited by Prof. His (§170, *a*) as examples of my many terms that are objectionable be-

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[1] In this connection two remarks are naturally suggested: (1) *Medipedunculus* is an adjectival locative, it and its correlatives, *praepedunculus* and *postpedunculus*, constituting one of the most perfect groups of that kind; §§29, 189. (2) The obtrusively Latin termination of these words, as well as the length of the words themselves, forced upon me in 1884 (§62) the consideration of the whole subject of paronymy.

[2] In the absence of adequate context or prior definition, would any reader imagine that *spongiocyte* and *spongioplasm* refer to elements of the nervous tissue?

cause they are "new." In the lexicon of Liddell and Scott *κοιλία ἐγκεφάλου* is quoted as in good and regular standing among Greek medical writers. According to Burdach ("vom Baue und Leben des Gehirns," 1819-1822, II, 301, 378, 380), Galen designated the "fourth ventricle" as *κοιλία ὀπισϑίου ἐγκεφάλου*, *τετάρτη κοιλία* and *ὀπισϑία κοιλία* ("De usu partium," Lib. VIII, C.XII. p. 170); the "third ventricle" as *μέση τρίτη κοιλία* (idem. IX, III, 172); and the "lateral ventricles" as *προσϑίαι κοιλίαι* ("De odoratus instrumento," II, 110). *Coelia* is then certainly not "new." Had Prof. His said *unusual*, his objection would have been more nearly justified by the facts, although in recent encephalic literature on both sides of the water compounds of *coelia* are more and more frequently encountered.

§202. In favor of *coelia* (English *celia* or *cele*)[1] in place of *ventriculus* may be urged the following:

1. Its Greek origin renders it compoundable regularly and euphoniously with the characteristic prefixes already employed in the segmental names, e. g., *mesencephalon*, etc.

2. These compounds are mononyms and therefore capable (§47) of inflection, (e. g., *mesocoeliae*), derivation (e. g., *mesocoeliana*), and adoption into other languages without material change; e. g., English, *mesocele;* French, *mesocoelie;* German, *Mesokölie;* Italian, *mesocelia.*

3. The various national paronyms thus formed are likewise capable of derivation; e. g., *mesocelian.*

4. There is classic authority for the use of *coelia* in the sense of encephalic cavity; §201.

5. These ancient usages are assumed to be familiar to educated anatomists, who therefore should recognize the compounds with little or no hesitation.

6. The compounds are so euphonious and so obviously correlated with the segmental names as to be learned and re-

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[1] As already remarked (W. & G., '89, §80, note), in an English sentence the word by itself might be either ambiguous or pedantic and the general term *cavity* commonly answers the purpose; see §48, and (for the replacement of *oe* by *e*) §69.

membered easily even by general students, and by those who may not have had a classical training.[1]

7. In recent times it has been independently proposed by two anatomists, teachers as well as investigators.[2]

8. It has been adopted more or less completely by three of the older American neurologists, Henry F. Osborn, ('82, '84, '88), E. C. Spitzka ('81, '84), and R. Ramsay Wright ('84, '85), and unreservedly by eight of the younger, W. Browning, T. E. Clark, P. A. Fish, Mrs. S. P. Gage, O. D. Humphrey, B. F. Kingsbury, T. B. Stowell, and B. B. Stroud.

§203. It will be noted that among the advantages of *coelia* over *ventriculus* is not enumerated its freedom from ambiguity. Theoretically, of course, *ventriculus* (*encephali*) might be mistaken for *ventriculus* (*cardiae s. cordie*). Practically, however, the context would almost infallibly obviate misapprehension.[3] Hence from my point of view, the absolute unambiguity of *coelia* and its compounds would not in itself justify its replacement of *ventriculus.* It would be a *causa vera*, but hardly a *causa sufficiens.*

§204. The concluding remark of Professor His may be said to "cap the climax" of his ill-founded criticism. The characterizations, "völlig neuen" and "grossentheils recht fremdartig Klingenden," could hardly have been more sweeping

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[1] Among the hundreds of such students at Cornell University and at the Medical School of Maine who have gained their practical and theoretic knowledge of encephalic morphology by means of these compounds no special difficulty has ever been experienced.

[2] My propositions first appeared in the paper, '81, *b*, March 19 and 26, 1881. On the fifteenth of August, 1882, Prof. T. Jeffery Parker read before the the Otago Institute of New Zealand a paper ('82) in which *mesocoele* and similar compounds were introduced, although he was evidently quite unaware of my prior publication. The terms were also employed in his "Zootomy" ('84) and in a later paper ('86).

[3] My previous reference (§199) to the polyonymic derivative, *sulcus limitans ventriculorum*, was not for the sake of demonstrating the ambiguity of that term but to illustrate the inconsistency of the implied demand of Professor His (§170) that all terms must be self-explanatory and require no definition.

had I proposed to replace Latin by Choctaw.[1] Any anatomist, unprejudiced, and not above conceding the possibility that some good thing may come out of the American Nazareth, who will candidly compare the terms in Table VI (Part VII) will admit that in the second column a comparatively small number are new in the strict sense of the word, and that the large majority are either identical with those in the first, or differ therefrom merely in the omission of useless words, or in the replacement of adjectives by prefixes of like signification.[2]

§205. *Comments and criticisms by Prof. A. von Kölliker.* Early in 1892, about a year after the date of the first letters from the secretary of the German committee (§138) its chairman spoke as follows ("Nervenzellen und Nervenfasern," *Biolog. Centralblatt*, XII, 36, Jan. 30, 1892):

> "So haben amerikanische Gelehrte im letzten Jahre einen Versuch zur Verbesserung einiger Teile der anatomischen Nomenklatur unternommen, und hoffen wir, dass dieselben unserer Einladung zu gemeinsamer Arbeit entgegenkommen werden. Sollte es gelingen, wenigstens die lateinischen Namen in den morphologischen Wissenschaften zu einem Gemeingute aller zu machen, so wäre hiermit offenbar ein grosses Ziel erreicht."

§206. Following is a translation of the above:

> "During the past year American scientists have made an effort toward the improvement of some parts of Anatomic Nomenclature. We hope they will look favorably upon our invitation to join us in our work. Should we succeed at least in making the Latin names in the morphologic sciences common property, a great end would thereby be attained."

§206. The foregoing implies that the coöperation of American anatomists not only was desired but had been asked. I am not aware that other members of the American commit-

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[1] At that time, although my principal article on terminology had not been read by Professor His (see Part VI), the lists of terms preferred by me were in his hands (§140, note), so that no claim can be entertained that he referred merely to what he assumed my proposals "tended" to bring about.

[2] Just as this goes to the printer (Nov. 13, 1896) there reach me several reprints of the note by Professor His in the *Anat. Anzeiger* (XII, 446-448, November, 1896) entitled "Herr Burt Wilder und die Anatomische Nomenclatur." His remarks will be considered in connection with our correspondence, Part VI.

tees corresponded with members of the German committee upon the subject of anatomic nomenclature, and the request of Dr. Krause for our reports and for my papers could hardly be interpreted as an official invitation to coöperate; see §137.

§207. So far as I am aware, the only other utterance of Prof. Kölliker upon the subject constitutes a paragraph on p. 814 of the second volume of his "Gewebelehre" in the part which was published, I believe, in the spring of 1896. It is as follows:

> "Die Nomenklatur anlangend, habe ich mich selbstverständlich in diesem §, wie in dem ganzen Buche, an die bekannten Beschlüsse der Kommission der anatomischen Gesellschaft und den *Nomenclator anatomicus* derselben gehalten. Die in den letzten Jahren von Amerika ausgehende anatomische Nomenklatur halte ich für vollkommen verfehlt und für so unverwendbar, dass es mir unmöglich ist, Abhandlungen zu lesen, denen dieselbe zu Grunde gelegt ist. Man kann doch von einem Gelehrten, der eine ordentliche Schulbildung genossen hat, nicht verlangen, dass er die vielen Barbarismen dieser Nomenklatur, wie *metatela*, *metaplexus*, *auliplexes*, *diaplexus*, *ectocinerea*, *cephalad*, *caudad*, *dorsad*, *cephalo-dorsad*, *ventro-caudad*, *dorso-caudad*, *hemicerebrum* u. s. w. ruhig annehme und bei einer grossen Anzahl anderer Worte, wie *terma*, *proton*, *pero*, *prosoterma*, *diaterma*, *supraplexus*, *aula*, *alba*, *crista*, *diacoele*, *mesocoele* u. s. w. erst hingehe und lerne, was dieselben bedeuten sollen. Als ältester deutscher Anatom wird es mir wohl erlaubt sein, den amerikanischen Kollegen den Rath zu geben, auf dieser Bahn nicht weiter fortzuschreiten, sonst würde es im Laufe von einigen Jahren dazu kommen, dass man sich hüben und drüben nicht mehr verstünde und jeder wissenschaftliche Verkehr unmöglich würde."

§208. Following is the translation:

> "As regards nomenclature I have of course maintained in this section, as in the whole book, the known conclusions of the committee of the anatomische Gesellschaft and the *Nomenclator anatomicus* thereof. The anatomic nomenclature coming from America in recent years, I regard as a complete failure, and as unavailable, because it is impossible for me to read articles based thereon. One cannot ask of a scholar who has received an accurate education that he accept quietly the many barbarisms of this nomenclature, such as *metatela*, *metaplexus*, *auliplexus*, *diaplexus*, *ectocinerea*, *cephalad*, *caudad*, *dorsad*, *cephalo-dorsad*, *ventro-caudad*, *dorso-caudad*, *hemicerebrum*, etc. and with a great number of other words like *terma*, *proton*, *pero*, *prosoterma*, *diaterma*, *supraplexus*, *aula*, *alba*, *crista*, *diacoele*, *mesocoele*, etc. first go to work to learn what they mean. As the oldest German anatomist, it may be permitted me to advise our American colleagues not to continue farther in this direction lest, in the course of a few years, it come

about that we cannot understand each other in the two countries, and hence all scientific intercourse will become impossible."

§209. The age of Prof. Kölliker, his magnificent services in the advancement and diffusion of science, and the evident sincerity of his regret at American departures from what he regards as terminologic rectitude, all demand serious rejoinder.

§210. Among the terms that one must "go to work to learn what they mean," *crista* (*fornicis*) designates a feature of the brain which, so far as I know, was first described by me in 1880 ('80, *g;* W. & G., '82, §1214; Mrs. Gage, '93, 283-284); as its discoverer, I may be permitted to assign it a name. *Pero* was proposed by me ('81, *b*) for the soft ectal layer of the Bulbus olfactorius which, in hardened animal brains, often peels off the firmer ental "core" like a boot; but the word is seldom needed. If the *terma* (§194) pertains to two encephalic segments, *diaterma* and *prosoterma* seem to be both appropriate and intelligible. *Mesocoele* and *diacoele* (Latin, *mesocoelia* and *diacoelia;* English, *mesocele* and *diacele*) have been discussed directly or indirectly above (§201-203). *Supraplexus*, (introduced, I think by Mrs. Gage) would certainly be supposed to indicate a plexus in the roof of some part of the brain cavity. *Alba* could hardly suggest anything else than the *substantia alba* of the German list; see §116.

§211. *Aula.*—After years of confusion, doubt, and even distress of mind, induced by the failure to reconcile the facts of development and comparative anatomy with the prevalent nomenclature of the brain, in 1880 ('80, *d, e, f;* '81, *b, d*) I proposed *aula* upon grounds formulated two years later as follows (W. and G., '82, §1065):—

(1) "To substitute brief single words for the phrases, "ventriculus communis," "ventriculus lobi communis," mesal part of the "common ventricular cavity," "foramen Monroi," etc.

(2) Because the phrase most commonly employed, *foramen Monroi*, is used to designate at least three different cavities or orifices: (*a*) The cavity by which either paracoelia ["lateral ventricle"] communicates with the mesal series of cavities; (*b*) The two lateral orifices together with the intervening space; (*c*) The mesal [cephalic] orifice of the diacoelia. We have been unable to ascertain by whom

the phrase was first employed, and the description by Monro *secundus* (1783), in whose honor it was applied, is somewhat vague.

(3) In order to indicate our opinion of the desirability of recognizing the aula as morphologically an important element of the series of encephalic cavities."[1]

§212. *Proton.*—This neuter noun was used by me ('93, *a*, §46, note) to designate the comparatively undifferentiated mass in which two or more parts might afterward be distinguishable. It is free from certain obvious and by no means inconsiderable objections that may be brought against *Anlage* and *fundament* as English words. It is subject to inflection, and may be adopted into any language. In many derivatives or compounds it is associated in the minds of all educated persons with the general idea of primitiveness. Its employment is in harmony with the following phrases from Aristotle cited for me by Prof. B. I. Wheeler:—*τὸ πρῶτον; ἡ πρώτη ὕλη; ἡ πρώτη αἰτία.*

§213. In short, all my regrets for the errors already confessed (§ 71) and for others of which I may be convicted, together with all my doubts regarding certain of the terms not as yet acted upon by the American committees, shrink into the background of my mind as I reflect upon the nature and significance of *aula* and *proton*, and upon the advantages that have been and may be gained from their employment.

§214. In the foregoing extract (§207) I suppose "Barbarismen" means *verba hybrida*, i. e., words formed by the conjunction of Latin and Greek elements. If so, one of the six specified organonyms, viz., *auliplexus*, must be exempted from the stigma since *aula*, although derived from the Greek *αὐλή* is a Latin word in good standing. To the remaining five I add five other neural mononymic hybrids for which I am responsible. In a parallel column of Table IV are given the equivalents either as in the German list or as they would be regularly formed. In another (the first) column are placed an equal number of hybrid words selected from the German list, and hence, I infer, sanctioned by the President of the Commission. With

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[1] With some of the lower vertebrates (e. g., *Chimaera*, '77, *a*,) the aula is much more extensive than either of the "lateral ventricles" with which it is connected through the two portae.

both groups I have italicized the Greek element which (so far as appears in a standard lexicon) failed to be adopted (by paronymy) into classic Latin. Of course the abstract etymologic immorality involved in the two sets of irregular connections is the same. The offspring of the second set surely compare favorably with the first in point of comeliness,[1] and their utility as savers of labor and time may be estimated by comparison with their polyonymic equivalents in the third column.

TABLE IV.

Hybrid words contained in the German List.	*Hybrid words for which the writer is responsible.*	*Polyonymic equivalents of the words in the second column, mostly from the German List.*
*Epi*durale	*Meta*tela	"Lamina chorioidea epithelialis" [ventriculi quarti]
*Meso*varicus	*Dia*tela	"Lamina chorioidea epithelialis" [ventriculi tertii]
*Par*umbilicales	*Para*tela	"Lamina chorioidea epithelialis" [ventriculi lateralis]
*Par*olfactorius	*Meta*plexus	"Plexus chorioideus ventriculi quarti"
Peri*chorioidiale*	*Dia*plexus	" " " tertii"
Supra*choroidea*	*Para*plexus	" " " lateralis"
*Chorio*capillaris	*Ecto*cinerea	"Substantia corticalis"
*Pterygo*palatinus	*Ento*cinerea	"Stratum griseum centrale"
*Pterygo*mandibularis	*Hemi*cerebrum	Dimidium cerebri laterale
*Phrenico*costalis	*Hemi*septum	Dimidium septi pellucidi laterale

§215. The reasonable view of hybrid terms seems to me to be embodied in the following remark of Barclay ('03):

> "Notwithstanding the opprobrium attached by some to certain connections and intermarriages among harmless vocables, I should be inclined not to reject the coöperation of the two languages (Greek and Latin) where experience shows it to be convenient, useful or necessary."

Abstractly, we may all prefer horses to mules, but this need not hinder us from recognizing that, under certain circumstances, the latter are more efficient than the former, and that, in a given case, a horse may not be even so handsome as a mule.

§216. The verdict of Prof. Kölliker that the nomenclature coming from America in recent years is a "complete failure"

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[1] The first four from the German list might have been replaced from the same source by the less acceptable "sphenopalatinum," "sphenoöccipitalis," "occipitomastoidea" and "squamosomastoidea."

because he cannot read the articles based thereon, approximates what has been called "the erection of the limitations of one's individual experience into objective laws of the universe." I sincerely trust that he may some day concede the validity of these two propositions:—(1) A considerable number of investigators and advanced instructors on both sides of the ocean have employed the "American" system more or less systematically. (2) Judging from my own experience as learner and teacher, the hundreds of students, general and special, upon whom that system has been practised since 1880, have either saved so much time, or gained so much more information within a given time, as to make its employment "worth while" even when the later environment proved unfavorable to its permanent use.

§217. In concluding this response to the criticism of "the oldest German anatomist", I venture to call his attention to the different reception accorded my plans for terminologic simplification by two other anatomic teachers well advanced in years, viz., Joseph Leidy (§ 56, note) and Oliver Wendell Holmes (§ 79). In order also that I may not appear unmindful of the fact that the assimilation of verbal novelties becomes less easy with increasing age,[1] I reproduce the concluding paragraph of my second paper upon the subject ('81, *b*):

> "The beginner can learn the new terms even more easily than the old, and at any rate he has nothing to forget. But the trained anatomist shrinks from an unfamiliar word as from an unworn boot; the trials of his own pupilage are but vaguely remembered; each day there seems more to be done, and less time in which to do it; nor is it to be expected that he will be attracted spontaneously toward the consideration that his own personal convenience and preferences, and even those of all his distinguished contemporaries, should be held of little moment as compared with the advantages which reform may insure to the vastly more numerous anatomical workers of the future."

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[1] The *argumentum ad hominem* is ungracious at the best, and the occasions for its employment in this paper have been too numerous already. But when I recall the delay and mystification inflicted upon me and my students by the variety and heterogeneity of terms, Latin and vernacular, with which most German treatises upon encephalic anatomy literally bristle (§§ 58-60, 169, note), I cannot but feel that, however sincere may be the repentance therefor among the anatomists of that nation, the needed reform should have been practised for a somewhat longer period before others were rebuked.

§218. Under the limitations of time, space and competence, I have now responded to the criticisms of the Anatomische Gesellschaft, the German committee, and three individual members thereof. However unfounded, unwise, or even unjust some of those criticisms may appear to me, I am disposed to believe that they were prompted by a wish to further what the critics regard as the best interests of anatomic science. They will, therefore, I trust, credit me with a similar motive in urging upon them as anatomists, and especially as German anatomists, the earnest consideration of one of the topics discussed in the earlier portion of this paper, viz., Paronymy as opposed to Heteronymy (§§43,85, e).

§ 219. Unfortunately, upon this point (which seemed to me in 1885 so important that it was the subject of my address as president of the American Neurological Association '85, *c*) I find myself unable as yet to determine what view is held by the German committee. Its secretary has declared (§ 159, 4) "that each nation can translate the Latin (international) name after its own fashion;" also (§ 158, 1) that German designations [heteronyms] in so far as they are not already established, or so far as they are really necessary, are left to the free choice of the individual.

§ 220. Whatever be the real or intended purport of the foregoing, the latest publications of the chairman of the commission ("Gewebelehre"), and of the member who has most fully discussed the subject, contain many and even diverse German vernacular equivalents of the Latin terms recommended by them. The article of Prof. His ('95, *a*) yields at least a score of such which have no etymologic relation with the Latin terms. It seems to me that, with the exception of *Gehirn* and possibly a few others (§ 48), the systematic employment of paronyms (§ 46) would greatly facilitate the comprehension of German writings by anatomists of other nationalities, and especially by students, without materially embarassing the Germans themselves.

§221. The feasibility of this method was exemplified in some degree in 1889 upon the "Table of Paronyms" (W. & G., '89, 530-531). I now venture to offer in Table V what seem to me appropriate German paronyms of most of the Latin terms adopted by the American Neurological Association (§80). So far as possible either the actual paronyms, or analogous pre-

TABLE V.

	Some of the Latin terms adopted by the Amer. Neurol. Asssociation.	*German paronyms.*	*Examples of the use of these paronyms, or of analogous ones, by German writers.*
1	Calcar	Kalkar	Kalkig
2	Callosum	Kallosum *s* Callosum	
3	Chiasma	Chiasma	"Chiasmas" (Onufrowics, '87, 12)
4	Claustrum	Claustrum	"Cerebellumgebiet" (His, '80, 26)
5	Clava	Clave	Olive
8	Cuneus	Cuneus	
9	Dentatum	Dentatum	"Ablegat."
10	Dura	Dura *s.* Dur	
11	Epiphysis	Epiphyse	Krause, '79, 780
12	Falx	Falx	
13	F. calcarina	Kalkarinfissur	
14	F. centralis	Centralfissur	"Centralcanal" (Henle, '79 231.)
15	F. collateralis	Collateralfissur	"Collateralfurche" (Wernicke, '82, I, 19)
16	F. hippocampi	Hippokampalfissur	
17	Fornix	Fornix	"Fornixtaenien"(His, '95, 167) "Fornixschenkel" (Schwalbe, '81, 464)
18	Hippocampus	Hippokamp	
19	Hypophysis	Hypophyse	"Hypophysenblase" (Schwalbe, '81, 477)
20	Infundibulum	Infundibulum	"Cerebellumgebeit" (His, '80, 26)
21	Insula	Insel	(Henle, '79, 170)
22	Lemniscus	Lemniscus	
23	Mesencephalon	Mesenkephal *s.* Mesencephalon	"Rhinencephalons" (His, '95, 175)
24	Monticulus	Montikel	"Follikel" (Schwalbe, '81, 473)
25	Oblongata	Oblongat	Advocat
26	Oliva	Olive	"Nebenolive" (Schwalbe, '81, 615)
27	Operculum	Operculum	"des Operculums," *Jen. Zeitschr.*, XXIX, 25
28	Pallium	Pallium	"des Spleniums"
29	Pia	Pia	"Piaplatte" (Edinger ? ?)
30	Pons	Pons	"Ponsfasern" (Edinger '89, 153)
31	Praecuneus	Präcuneus	
32	Pulvinar	Pulvinar	
33	Striatum	Striatum *s.* Striat	"Ablegat"
34	Tegmentum	Tegmentum *s.* Tegment	"Moment"
35	Tentorium	Tentorium	
36	Thalamus	Thalamus	"Thalamuskern" (Schwalbe, '81, 711)

cedents therefor, have been selected from German writings. In the other cases the suggestions may not be always well-founded.

Part VI. Correspondence with Professor Wilhelm His.

§222. The general occasion for the existence of this Part was stated in the Introduction, §4. The hope, entertained at the time that was written and expressed at a later period (§171), that Prof. His might publicly correct all his errors of omission and commission, has not been realized in his article (just received in the *Anatomischer Anzeiger*, XII, 446-448, Nov., 1896, hence the correspondence is most regretfully submitted. The only changes consist in the omission of unessential paragraphs, and in the addition of notes, or of words in brackets.

§223. From the writer to Prof. His, Dec. 3, 1895.

Prof. W. His, Dear Sir:—Not until a week ago was able I to read your article in the *Archiv f. Anatomie* etc., 1895, "Die anatomische Nomenclatur," wherein, on pages 6 and 7, you do me the honor to discuss my views especially with reference to encephalic terms.

It is my intention to present the subject at the coming meeting of the Association of American Anatomists, on the 26th of this month, and before doing so I desire to obtain from you answers to the subjoined queries. It will be a favor to me if the answers, or as many as possible of them, can reach me before the meeting, and it will be an advantage to our discussions if you permit them to be made public.

Regretting to differ with you, and to ask you to perhaps inconvenience yourself in order to reach me in season, I have the honor to remain, Very respectfully yours,

BURT G. WILDER.

1. I see no reference to the writings of Richard Owen or Pye Smith. The latter (*Jour. of Anat. and Physiology*, Oct. 1877) published an article of 22 pages and insisted upon the sufficiency of *thalamus* which you concede. The former introduced *postcava* and *precava* and ("Anat of Vertebrates," III p. 136) gives a list of fissures, all the names being mononyms and some (*callosal*, *supercallosal* and *subfrontal*) apparently unobjectionable. Why were these not included in the column of synonyms by "various authors" [in the protocols of the committee? §178, 3].

2. Excepting some compounds of *encephalon*, nearly all the mononyms upon your list of encephalic terms, about twenty-five in number, had already been selected and adopted by me. Was not this

coincidence worth mention as indicating the possibility of some degree of harmonious coöperation between us?

3. You say "Wilder und seine Collegen verlangen lauter Mononyme." This is correct [but only in the sense of *prefer*; see §172]. You then add, "Sie sagen, z.B. *praecornu*, *postcornu* und *postcava*." These words are used by me, but not, so far as I know, by other members of the American Committees,[1] although they recommend the employment of CALCAR for *hippocampus minor*, HIPPOCAMPUS for *h. major*, PONS for *pons Varolii*, INSULA for *insula Reilii*, and PIA and DURA for *pia mater* and *dura mater* respectively.

4. You refer to the principle of mononymy. But you do not seem to have gathered, even from my "Paronymy *versus* Heteronymy as Neuronymic Principles" [85, *c*], that mononyms are preferred by us to polyonyms not so much because they are usually shorter, but because, whatever their length, they are capable of two desirable modifications, *viz.*, (*a*) inflection as adjectives (*e g.*, *thalamicus*, *callosalis*, *duralis*, etc.) and (*b*) adoption by paronymy into other languages, (*e g*, *hippocampus*, *hippocampe*, *hippocamp*, *Hippokamp*, *hippocampo*). Am I to infer that this feature of the matter was unknown to you, or regarded as slight in importance?

5. You say "Sprachwidrige Wortzusammensetzung enthält aber Wilder's Liste sehr viele" It would not be without probability or precedent that errors should occur among so large a number of terms, but I must insist upon the specification of my ungrammatic verbal combinations In particular I ask fuller grounds of objection to *medipedunculus* [§198]

6. You mention certain papers by me [as "eine Reihe von kleineren Aufsätzen und Broschüren"; §170, *d*, note 2]. Their fewness [four], their brevity, and their recent dates [1890-1892] would indicate that I had done little on the subject and that my views are correspondingly unimportant. Yet my first paper on [encephalic] Nomenclature was in 1880 and I have published something almost annually since upon it. The article [W. and G, '89] in the "Reference Handbook" [of the Medical Sciences, VIII, 515-533, 1889] was, so far as I know, the fullest discussion of late years; a copy was sent to Dr. Krause [secretary of your committee] about May, 1891, and his letter of April 12, 1892, informed me that it had been "set in circulation among the Committee." It is also mentioned in most of my papers or documents printed since 1889. In 1892, the American Association for the Advancement of Science adopted unanimously the Report of the Committee (of which I am not a member) on Biological

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[1] As stated in the Introduction, §3, I desire to free others from responsibilities which they have not assumed. So far as may be inferred from the entire absence of later reference to this point upon the part of Professor His, an allegation, absolutely unfounded and casting upon several American anatomists what they may regard as serious discredit, may be publicly made and neither substantiated nor withdrawn.

Nomenclature [§85, *f*, and note[2]], including a characterization of the Handbook article "as representing an epitome of the whole subject, with suggestions for future progress." A copy of that Report was sent to you. Is your absolute silence as to the article to be interpreted as indicating that you not only never saw it, but never heard of it, or had no idea of its scope?

§224. From Professor His to the writer, Dec. 15, 1895.

SEHR GEEHRTER HERR COLLEGE: Ihr Brief vom 3d M. mit den 6 fragen trifft erst heute bei mir ein, und es ist mir zweifelhaft, ob meine Antwort bis zum 26 in Ihren Händen sein kann. Ohne in Einzelnheiten einzutreten, was wohl ziemlich nutzlos sein würde, hebe ich hervor, dass es sich in dieser Sache nicht um eine persönliche Angelegenheit handelt, da die anatomische Gesellschaft als solche zu Ihren Bestrebungen Stellung genommen hat. Sie finden die Erklärung der anatomischen Gesellschaft im Bericht [etc.; see this article §147].

Hochachtungsvoll Ihr ergebener, W. HIS.

§225. Translation of the above letter from Professor His, Dec. 15, 1895.

ESTEEMED COLLEAGUE: Yours of the 3d containing six queries was received to-day and I doubt whether my answer can reach you for the 26th. Without entering into details, which would very likely be useless, I point out that this is not a personal matter, since the Anatomische Gesellschaft as such is opposed to your efforts. You will find its declaration in the Report, etc. [see §147 of this article].

Respectfully yours, W. HIS.

§226. From the writer to Professor His, Jan. 3, 1896.

PROFESSOR HIS, DEAR SIR: Your favor of Dec. 15th reached Philadelphia after the close of the last session of the Association of American Anatomists. *I infer that you had no objection to its publication.* Pray accept my thanks for your promptness, and for the references to the published opinion of your committee. This I was acquainted with. It is practically a declaration of conservatism which I hope to find time to comment upon. I conclude that you regard the queries in my communication of Dec. 3, 1895, as covered by the committee's opinion. Whatever view might be taken as to the first four, I feel justified in calling upon you personally for explicit responses to the last two, *viz.*:—What "ungrammatic verbal combinations" occur in my recent lists? What explanation have you for intimating that my first publication on Anatomic Nomenclature was dated in 1889 instead of 1880, and for ignoring the article "Anat. Terminology" in the "Reference Handbook of the Medical Sciences," 1889?

The immediate question is, What is due to those continental anatomists who, in the absence of my lists of terms or of the publications by myself and other Americans who have more or less completely adopted them, may have been unduly influenced by the absence of those terms from the Committee's lists of synonyms, and by the serious omissions and errors embodied, however unintentionally, in your article?

It seems to me not too much to ask of you to supply the opportunity for independent comparison and judgment by reproducing in your *Archiv* the accompanying List of Neurologic and Vasal Terms adopted by your Committee, the terms preferred by me in parallel columns, the accompanying commentaries by me and such as you may think best to add, and the correspondence of which this forms a part.

I have the honor to remain, Very respectfully,
Your obedient servant, BURT G. WILDER.

§227. The further correspondence between Professor His and myself was as follows:—Second letter from him, Feb. 29, 1896. Third from me, Aug. 11. Third from him, Aug. 27. Fourth from me, Sept. 28. Although my third contained the statement that I was editing our correspondence for publication, and the third from Professor His offered no objection thereto, after consultation with the editors of this journal it has been deemed best to summarize the later letters, and to include the article (His, '96) already referred to (§222). As indicated at the outset of my second letter (Jan. 3, 1896; §226) I felt that he had tacitly granted my request for permission to publish his first letter (§224).

§228. At this stage I should like it understood that, in originally addressing Professor His directly rather than in the columns of a journal, I had two motives, *viz.*, *First,* the belief that the impending discussion of Anatomic Nomenclature by the Association of American Anatomists would be facilitated by the information sought. *Secondly,* the sincere desire to avoid a public controversy by affording to one whom I regarded as mistaken the opportunity to modify his statements voluntarily. This desire was in accordance with the sentiment, long entertained, but first expressed six years ago in this journal ('91, *b,* 201-202) that, "since everyone makes mistakes, the interests of all concerned would be best subserved by the adoption of the custom of each correcting his own, either as soon as discovered or periodically; a sort of scientific confession of sins. The natural corollary to this would be that each well-disposed discoverer of another's faults would inform him privately so that he might make prompt correction. This plan I have followed in several cases, and have reason to believe it has served to avoid personal irritation and the needless repetition of criticism."[1]

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[1] The lamentable failure of the plan in the present case does not lessen my confidence in its essential soundness.

§229. The second letter of Professor His contained no replies to my questions, and evinced no disposition to discuss the subject publicly; on the contrary it declared that he had given up all connection with nomenclature, and preferred to devote his time to other studies.

§230. In order to appreciate the situation from my standpoint there should be borne in mind certain facts, and certain propositions that are unlikely to be contested:—(*a*) Professor His not only originated the German movement for a revised nomenclature, but was a member of the special committee of three on the "Redactionsausschuss;" (*b*) he had set forth the aims, methods and results of the entire committee in an extended article; (*c*) having assumed such responsibilities, it was his duty to ascertain what had been done already; (*d*) had my own labors been wholly ignored I should have contented myself with my associates in this respect, Barclay, Whewell, Owen, Pye-Smith, and others; (*e*) but, in connection with a somewhat extended animadversion upon my views, what purported to be a list of my "chief publications" upon nomenclature omitted that which was most comprehensive; (*f*) under date of April 12, 1892 (§142), the secretary of the German committee had assured me that a copy of my principal article had been set in circulation among the members of the committee; (*g*) inquiries dated Dec. 1, 1895 and July 10, 1896, as to whether it had actually been transmitted to Professor His, remained unanswered by the secretary; (*h*) the last of the six inquiries accompanying my first letter (§223, 6) might have been answered at once and in a single word; (*i*) there would then have remained merely the explanation of his non-acquaintance with the article in question.

§231. On the eleventh of August, after waiting five months in the hope that reflection might convince Professor His that his previous letters did not meet the fundamental requirements of the situation, I reminded him that the six points at issue between us fell into two distinct categories; that points 1, 2 and 4 (indicated by the sections so numbered in my first letter) called for the exercise of a certain amount of professional courtesy, and that he was clearly within his rights in declining to take the time required for their elucidation; but that the other three had no necessary connection with nomenclature, and that courtesy need not be invoked in dealing with them. He had brought a general indictment, *viz.*, as to the existence of "many ungrammatic verbal combinations in my lists" (§223, 5), and he was bound to furnish specifications. He had uttered a charge ("Wilder und seine Collegen verlangen lauter Mononyme," §§172, 223, 3) which was either ambiguous or unfounded, and he was bound to explain or withdraw it. While undertaking to enumerate my "hauptsächlichste Schrifte," he had failed to mention the principal one, and he was bound to account for either his ignorance of the facts or for his failure to state them.

§232. To this Professor His replied under date of Aug. 27. His sentiments are expressed in his article (His, '96) of the same date published two months later. The original is readily accessible, but a translation is here appended.[1]

"*Mr. Burt Wilder and Anatomic Nomenclature.*

By Wilhelm His.

Some time after the publication of the Nomenclature adopted by the Anatomical society at Basel, Professor Burt Wilder of Ithaca, N. Y., U. S. A., complained to me by letter concerning the manner in which his own efforts at simplification of anatomic nomenclature had been mentioned in the introduction to the BNA[2] Mr. Wilder clothed his complaints in the form of personal questions and furthermore expressed the desire to publish my answers at the same time with his questions. This is a somewhat inquisitorial proceeding, unusual hitherto in intercourse among scholars. In the present case, also, the question is not a personal difference between Mr. Wilder and myself but concerns matters that have had their formal settlement through the transactions at Basel. Moreover, the anatomical society has stated its views respecting the efforts of the American Nomenclature committee in a special declaration, signed by all the members of the commission[3] and by the Pres-

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[1] With the exception of this article by Professor His, all of the translations of German extracts and letters in the present paper have been kindly revised by my friend Fraulein Berthe J. Bartelmann, Instructor in German at Smith College, Northampton, Mass.

[2] Explained in a note upon the reverse of the title leaf of His, '95:—"Als abgekürtze Bezeichnung der in Basel angenommenen Nomina anatomica wird vorgeschlagen [BNA]".

[3] *Proceedings of the Anatomische Gesellschaft*, at the ninth meeting at Basel, edited by K. v. Bardeleben, Jena, 1895, p. 162. [It is doubtless through an oversight that this statement is not here qualified by the phrase, "present at Basel," as in the report quoted in §147. Of the eighteen members of the committee, nine were then present].

ident of the Society. In concert with my colleagues on the editorial committee, the Messrs. Waldeyer and W. Krause, I have refused consequently to answer the separate questions of Mr. Wilder, and have referred him to the above mentioned declaration. Likewise, I had to refuse a later and unreasonable demand to print in the *Archiv für Anatomie u. Physiol.* his brain-terms together with those of the BNA. My colleagues and I were of the opinion that such a proceeding is not incumbent upon me, and that Mr. Wilder should be asked to present his amendments to the special revision committee of the Anatomical Society.

"A letter just received from Mr. Wilder, very objectionable in its form, shows me however that he believes himself to have been injured by me through the intentional ignoring of his earlier publications reaching back to 1880, as well as his more comprehensive article, "Anatomical Terminology," in the "Reference Handbook of the Medical Sciences," VIII, 1889, p. 515-533."

"To that I feel it my duty to offer an explanation. I cited such of Mr. Wilder's papers, with the qualification *as the most important*, as at that time were at hand. The "Reference Handbook," little known in Germany, has never been in my hands, and by mischance the separate proof-sheets of the article referred to, which Mr. Wilder had sent to Mr. Krause in the year 1891 with a view to the information of our committee at that time, has not reached me. It was, Mr. Krause informs me, lost by one of the members. Indeed, I was not aware of the existence of this treatise when I wrote the introduction to the BNA., and an intentional neglect of the same is out of the question.

"In order however to avoid all reproach of injustice toward Mr. Wilder I present herewith his questions in the form revised by him [§223, 1-6]. Each reader has then the basis for independent judgment.

Saasgrund, Ct. Wallis, Schweiz, 27 August, 1896."

§233. To the letter written at the same time as the foregoing article I replied (Sept. 28) that the plainness and peremptoriness of my previous communication might have been avoided had my earlier letters received due consideration. There has emanated from Professor His no sign of regret for his omissions. his errors, or his delay in their rectification.

Part VII. List of the Neural Terms, about Five Hundred and Forty in Number, Adopted by the Anatomische Gesellschaft in 1895, together with Those now Preferred by the Writer.

§234. The special names are arranged in seven groups, corresponding with the six definitive encephalic segments (see Table VII) and the myelon (spinal cord). In accordance with the general rule the series begins with the first (most cephalic or "anterior") segment, and ends with the myelon.

§235. *First Column.*—These names are as in the German list published by Prof. His ('95, a, 80-87), excepting as follows:—(*a*) Some typographic errors may have escaped detection. (*b*) It was found impracticable to reproduce the original "middle heads" in their various typographic forms; so far as possible, however, the subordination of less to more comprehensive terms is indicated by "indents." (*c*) In addition to words, mostly genitives of proper names, bracketed in the original, there are here introduced in brackets some entire terms to facilitate the recognition of certain parts apparently not specified in the German list.

§236. *Second Column.*—These are the Latin terms now preferred by me. In some cases I have been in doubt as to the identity of parts indicated in the German list; in others as to the desirability of any designation at all. The capitalized names are those respecting the excellence of which, both as designations and as terms, I feel most fully assured.

§237. *Third Column.*—This contains the English forms, or Anglo-paronyms, of the Latin terms preferred by me. Often they are identical therewith, and in all cases the differences are so slight as not to hinder their recognition; §44-48.

§238. *Last Column.*—The signs refer to the adoptions of the Latin terms in the middle column. (*a*) The word *general* signifies that the term is in common use. (*b*) The capitals N., G., A., S., signify the formal adoption of the terms by the American Neurological Association (1896; §80); the Anatomische Gesellschaft (1895; §137); the Association of American Anatomists (1889; §81); and the American Association for the Advancement of Science (1892; §84). (*c*) The dates, '80-'96, are those of my own adoption of the terms in the middle column; see Part II and the Bibliography.

TABLE VI.

Termini Neurologici Generales.

	German Committee.	*Present writer.*	*Angloparonyms.*	*Adoptions.*
1	Nervus	NERVUS	Nerve	General
2	Ganglion	GANGLION	Ganglion	General
3	Substantia alba	ALBA	Alba	'80; §116
4	Substantia grisea	CINEREA	Cinerea	'80 “
5	Substantia gelatinosa	GELATINOSA	Gelatinosa	'96
6	Taenia telarum	RIPA	Ripa	'81
7	Ependyma ventriculorum	ENDYMA	Endyma	'81
8	[Liquor cerebrospinalis]	COELIOLYMPHA	Celiolymph	'89
9	Sulcus limitans ventriculorum	Sulcus interzonalis	Interzonal sulcus.	'96; §195
10	Nuclei nervorum cerebralium	Nidi	Nidi	'89; §123
11	Nuclei originis	Nidi originis	Nidi of origin	'89
12	Nuclei terminales	Nidi terminales	Terminal nidi	'89
13	Ramus communicans	RAMUS COMMUNICANS	Communicating ramus	General
14	Ramus anastomoticus	RAMUS ANASTOMOTICUS	Anastomotic ramus.	General
15	Nervus cutaneus	NERVUS CUTANEUS	Cutaneous nerve	General
16	Nervus muscularis	NERVUS MUSCULARIS	Muscular nerve	General
17	Nervus articularis	N. ARTHRALIS	Arthral nerve	'96
18	Plexus nervorum spinalium	PLEXUS NERVORUM SPINALIUM	Plexuses of the spinal nerves	General

Termini Neurologici Proprii.

I	**Rhinencephalon**	**Rhinencephalon**	**Rhinencephal**	**'81**
1	Area parolfactoria [Brocae]	Area parolfactoria	Parolfactory area	
2	Bulbus olfactorius	Bulbus olfactorius	Olfactory bulb	'81
3	Gyrus subcallosus	G. subcallosus	Subcallosal gyre	
4	Limen insulae	Limen	Limen	
5	Lobus olfactorius	Lobus olfactorius	Olfactory lobe	'81
6	Pars anterior (rhinencephali)	? ?	? ?	
7	Pars posterior (rhinencephali)	?	?	
8	Stria intermedia	Radix intermedia	Middle root	'81
9	Stria medialis	Radix mesalis	Mesal root	'81
10	Stria olfactoria lateralis	Radix lateralis	Lateral root	'81
11	Substantia perforata lateralis	PRAECRIBRUM	Precribrum	'89
12	Sulcus parolfactorius anterior	?	?	
13	Sulcus parolfactorius posterior	?	?	
14	Tractus olfactorius	Tractus olfactorius	Olfactory tract	
15	Trigonum olfactorium	Trigonum olfactorium	Olfactory trigon	

I	Rhinencephalon	Rhinencephalon	Rhinencephal	'81
16	[Ventriculus olfactorius]	RHINOCOELIA	Rhinocele	'81
17	[Pars olfactoria foraminis interventricularis]	Pars olfactoria aulae	Olfactory part of the aula	'93
18	[Pars anterior commissurae anterioris]	Pars olfactoria praecommissurae	Olfactory part of the precommissure	'93

II	Telencephalon	Prosencephalon	Prosencephal	'81
1	Hemisphaerium	Hemicerebrum (cerebrum *fere*)	Hemicerebrum (cerebrum commonly)	'82
2	Pallium	Pallium	Pallium	'89, G. N.
3	Fissura longitudinalis cerebri	F. intercerebralis	Intercerebral fissure	'89
4	F. transversa cerebri	Hiatus tentorii	Tentorial interval	'96
5	Gyri cerebri	GYRI	Gyres or gyri	'82, G.
6	G. profundi	VADA	Vadums	'89
7	G. transitivi.	ISTHMI	Isthmuses	'89; §197
8	[G. operti]	Subgyri	Subgyres	'89
9	[G. operientes]	Supergyri	Supergyres	'89
10	Sulci cerebri	FISSURAE	Fissures	'82; §121
11	[Fissurae cerebri]	FISSURAE	Fissures	'82
12	S. et F. operti	Subfissurae	Subfissures	'89
13	S. et F. operientes	Superfissurae	Superfissures	'89
14	Impressio petrosa	Impressio petrosa	Petrosal impression	
15	[Impressio confluentis]	Impressio torcularis	Torcular impression	
16	Fossa cerebri lateralis [Sylvii]	FOSSA SYLVII	Sylvian fossa	'89
17	Fissura cerebri lateralis [Sylvii]	FISSURA SYLVII	Sylvian fissure	'82
18	Ramus posterior	F. SYLVII (*fere*)	Sylvian f. (commonly)	'82
19	Ramus anterior ascendens	F. PRAESYLVIANA	Presylvian f.	'85
20	Ramus anterior horizontalis	F. SUBSYLVIANA	Subsylvian f.	'89
21	[Pars basilaris]	F. basisylviana	Basisylvian f.	'85
22	Lobi cerebri	Lobi cerebri	Cerebral lobes	General
23	Insula	INSULA	Insula	'80, A. G. N. S.
24	[Pars anterior]	Praeinsula	Preinsula	'89
25	[Pars posterior]	Postinsula	Postinsula	'89
26	[Sulcus centralis insulae]	F. TRANSINSULARIS	Transinsular f.	'89
27	Gyri insulae	G. INSULAE	Insular gyres	'89
28	G. longus insulae	G. longus insulae	Long insular gyre	
29	Gyri breves insulae	G. breves insulae	Short insular gyres	

II	**Telencephalon**	**Prosencephalon**	**Prosencephal**	**'82**
30	S. circularis [Reili]	F. circuminsularis	Circuminsular f.	'89
31	[Polus insulae]	Polus insulae	Insular pole	
32	Operculum	Opercula	Operculums	'89; §102
33	Pars frontalis	PRAEOPERCULUM	Preoperculum	'85
34	Pars parietalis	OPERCULUM	Operculum	'85; N.
35	Pars temporalis	POSTOPERCULUM	Postoperculum	'85
36	[Pars orbitalis]	SUBOPERCULUM	Suboperculum	'85
37	S. centralis [Rolandi]	F. CENTRALIS	Central fissure	'82, N.§120
38	G. centralis anterior	G. PRAECENTRALIS	Precentral gyre	'85
39	G. centralis posterior	G. POSTCENTRALIS	Postcentral g.	'89
40	[S. centralis inferior]	F. subcentralis	Subcentral f.	'89
41	[G. transitivus centralis]	ISTHMUS CENTRALIS	Central isthmus	'89; §197
42	[G. transitivus profundus centralis]	VADUM CENTRALE	Central vadum	'89; §197
43	Lobus frontalis	Lobus frontalis	Frontal lobe	General
44	[Pars postfrontalis]	Pars postfrontalis	Postfrontal portion	
45	[Pars praefrontalis]	Pars praefrontalis	Prefrontal portion	'89
46	Polus frontalis	Polus frontalis	Frontal pole	
47	Sulcus praecentralis [pars superior]	F. PRAECENTRALIS	Precentral f.	'96
48	S. praecentralis [pars inferior]	F. postfrontalis	Postfrontal f.	'96
49	G. frontalis superior	G. SUPERFRONTALIS	Superfrontal f.	'85
50	S. frontalis superior	F. SUPERFRONTALIS	Superfrontal f.	'85
51	G. frontalis medius	G. MEDIFRONTALIS	Medifrontal g.	'85
52	Pars superior	Pars dorsalis	Dorsal part	
53	Pars inferior	Pars ventralis	Ventral part	
54	[Sulcus frontalis intermedius]	F. MEDIFRONTALIS	Medifrontal f.	'85
55	Sulcus frontalis inferior	F. SUBFRONTALIS	Subfrontal f.	'85
56	G. frontalis inferior	G. SUBFRONTALIS	Subfrontal g.	'85
57	Pars opercularis	Pars opercularis	Opercular part	
58	Pars triangularis	Pars praeopercularis	Preop'rcular part	
59	Pars orbitalis	Pars subopercularis	Subop'rcul'r part	
60	G. rectus	G. mesorbitalis	Mesorbital g.	'96
61	S. olfactorius	F. olfactorius	Olfactory f.	'82
62	Gyri orbitales	G. orbitales	Orbital gyres	'89
63	Sulci orbitales	F. orbitales	Orbital fissures	'89
64	Lobus temporalis	Lobus temporalis	Temporal lobe	General
65	Polus temporalis	Polus temporalis	Temporal pole	
66	Sulci temporales transversi	F. transtemporales	Transtemporal fissures	'85
67	Gyri temporales transversi	G. transtemporales	Transtemporal gyres	'85
68	G. temporalis superior	G. SUPERTEMPORALIS	Supertemporal g.	'85
69	S. temporalis superior	F. SUPERTEMPORALIS	Supertemporal f.	'85
70	G. temporalis medius	G. MEDITEMPORALIS	Meditemp'ral g.	'85

II	Telencephalon	Prosencephalon	Prosencephal	'82
71	S. temporalis medius	F. MEDITEMPORALIS	Meditemporal f.	'85
72	G. temporalis inferior	G. SUBTEMPORALIS	Subtemporal g.	'85
73	F. collateralis	F. COLLATERALIS	Collateral f.	'85
74	G. fusiformis	G. SUBCOLLATERALIS	Subcollateral g.	'85
75	G. lingualis	G. SUBCALCARINUS	Subcalcarine g.	'85
76	Lobus occipitalis	L. occipitalis	Occipital lobe	General
77	Polus occipitalis	P. occipitalis	Occipital pole	
78	S. occipitalis transversus	F. paroccipitalis (*in parte*)	Part of the paroccipital f.	
79	G. occipitales sup'riores	?	?	
80	S. oc. superiores	?	?	
81	G. oc. laterales	?	?	
82	Lobus parietalis	Lobus parietalis	Parietal lobe	General
83	Lobulus parietalis superior	G. PARIETALIS	Parietal gyre	'89
84	Lobulus parietalis inferior	G. SUBPARIETALIS	Subparietal g.	'89
85	Sulcus interparietalis	Complexus fissuralis intraparietalis (?)	Intraparietal fissural complex	
86	[Pars postcentralis superior]	F. POSTCENTRALIS	Postcentral f.	'85
87	[Pars postcentralis inferior]	F. praeparietalis	Preparietal f.	'96
88	[Pars horizontalis]	F. PARIETALIS	Parietal f.	'85
89	[Pars occipitalis]	F. PAROCCIPITALIS	Paroccipital f.	'86
90	[S. praeparoccipitalis]	F. PRAEPAROCCIPITALIS	Preparoccipital f.	'86
91	[S. postparoccipitalis]	F. POSTPAROCCIPITALIS	Postparoccipital fissure	'86
92	[Gyrus transitivus paroccipitalis]	ISTHMUS PAROCCIPITALIS	Paroccipital isthmus	'86; §197
93	[G. transitivus opertus paroccipitalis]	VADUM PAROCCIPITALE	Paroccipital vadum	'86
94	Lobulus parietalis inferior	G. SUBPARIETALIS	Subparietal g.	'89
95	G. supramarginalis	G. marginalis	Marginal gyre	'85
96	G, angularis	G. angularis	Angular g.	'85
97	[S. intermedius]	F. intermedia (?)	Intermedial f.	'85
98	[S. exoccipitalis]	F. exoccipitalis	Exoccipital f.	'89
99	[F. calcarina externa]	F. lambdoidalis	Lambdoidal f.	'86
100	S. corporis callosi	F. CALLOSALIS	Callosal f.	'85
101	S. cinguli	[needless]		
102	Pars subfrontalis	F. SUPERCALLOSALIS	Supercallosal f.	'85
103	Pars marginalis	F. paracentralis	Paracentral f.	'85
104	S. subparietalis	F. praecunealis	Precuneal f.	'85
105	F. hippocampi	F. HIPPOCAMPI	Hippocampal f.	'82 G. N.
106	G. fornicatus	[needless]		
107	G. cinguli	G. CALLOSALIS	Callosal g.	'85
108	Isthmus gyri fornicati	Isthmus cinguli	Isthmus of the cingulum	'96
109	Uncus [gyri hippocampi]	UNCUS	Uncus	'82

II	Telencephalon	Prosencephalon	Prosencephal	'82
110	Substantia reticularis alba [Arnoldi]	Reticularis alba	Reticular alba	
111	Lobulus paracentralis	G. PARACENTRALIS	Paracentral gyre	'85
112	Praecuneus	PRAECUNEUS	Precuneus	'85 G. N.
113	F. parietooccipitalis	F. OCCIPITALIS	Occipital fissure	'85
114	F. calcarina	F. CALCARINA	Calcarine f.	'85 G. N.
115	F. occipito-calcarina	F. occalcarina	Occalcarine f.	'89
116	[S. postcalcarina]	F postcalcarina	Postcalcarine f.	'85
117	Cuneus	CUNEUS	Cuneus	'89 G. N.
118	[Isthmus cunei]	ISTHMUS CUNEI	Cuneal isthmus	'96
119	[Isthmus opertus cunei]	Vadum cunei	Cuneal vadum	'96
120	[S. adoccipitalis]	F. adoccipitalis	Adoccipital f.	'89
121	[Cuneus anterior]	CUNEOLUS	Cuneolus	'95
122	[S. inflecta]	F. inflecta	Inflected f.	'85
123	[S. fronto-marginalis]	F. fronto-marginalis	Fronto-marginal	'89
124	S. oc. laterales	?	?	

II. B. Cava et Corum Parietes.

II	Telencephalon	Prosencephalon	Prosencephal	'82
1	[Cavitas telencephali]	PROSOCOELIA	Prosocele	'86; §201
2	[Pars medialis foraminis interventricularis]	AULA (*fere*)	Aula (commonly)	'80; §211
3	[Pars lateralis foraminis interventricularis]	PORTA	Porta	'81; §211
4	Ventriculus lateralis	PARACOELIA	Paracele	'89
5	Pars centralis	CELLA	Cella	'82
6	Cornu anterius	PRAECORNU	Precornu	'81; §185
7	Cornu posterius	POSTCORNU	Postcornu	'81
8	Cornu inferius	MEDICORNU	Medicornu	'81
9	Corpus striatum	STRIATUM	Striatum	'80; N.
10	Nucleus caudatus	CAUDATUM	Caudatum	'89; §111
11	Caput nuclei caudati	CAPUT	Caput	'89; §26
12	Cauda nuclei caudati	CAUDA	Cauda	'89
13	Stria terminalis	Taenia	Tenia	'89
14	Lamina affixa	?	?	
15	Taenia chorioidea	RIPA	Ripa	'82
16	Lamina chorioidea epithelialis	PARATELA	Paratela	'89
17	Calcar avis	CALCAR	Calcar (§106)	'81; A.N.S.
18	(Bulbus cornu posterioris)	EMINENTIA OCCIPITALIS	Occipital eminence	'89
19	Eminentia collateralis	EMINENTIA COLLATERALIS	Collateral eminence	General
20	Trigonum collaterale	Trigonum collaterale	Collateral trigon	'96
21	Hippocampus	HIPPOCAMPUS	Hippocamp	'80 A. G. N. S.
22	Fimbria hippocampi	FIMBRIA	Fimbria	'81
23	Taenia fimbriae	RIPA	Ripa	'81
24	Digitationes hippocampi	Digitationes hippocampi	Hippocampal digitations	'96
25	Fascia dentata hippocampi	Fasciola	Fasciola	'81

II	Telencephalon	Prosencephalon	Prosencephal	'82
26	Commissura hippocampi	Fornicommissura	Fornicommissure	'89
27	Corpus callosum	CALLOSUM	Callosum (§111)	'80 N.
28	Splenium corporis callosi	SPLENIUM	Splenium	'80
29	Truncus corporis callosi	CALLOSUM (*fere*)	Callosum (commonly)	'80
30	Genu corporis callosi	GENU	Genu	'81; §26
31	Rostrum corporis callosi	ROSTRUM	Rostrum	'81
32	Lamina rostralis	Copula	Copula	'89
33	Striae transversae	Striae transversae	Transverse striae	'98
34	Stria longitudinalis medialis	Stria mesalis	Mesal stria	'96
35	Stria longitudinalis lateralis	Stria lateralis	Lateral stria	'96
36	Fasciola cinerea	Fasciola	Fasciola	'81
37	[Indusium]	Indusium	Indusium	'93
38	Fornix	FORNIX	Fornix	General
39	Crus fornicis	needless		
40	Corpus fornicis	FORNIX (*fere*)	Fornix (commonly)	'80
41	Taenia fornicis	Ripa	Ripa	
42	Columna fornicis	Fornicolumna	Fornicolumn	'84
43	Pars libera columnae fornicis	Pars libera fornicolumnae	Free part of the fornicolumn	'96
44	Pars tecta columnae fornicis	Pars tecta fornicolumnae	Concealed part of the fornicolumn	'96
45	[Crista]	CRISTA	Crista	'80; §210
46	[Carina]	CARINA	Carina	'81
47	Septum pellucidum	SEPTUM	Septum	'89; §26
48	Lamina septi pellucidi	HEMISEPTUM	Hemiseptum	'82
49	[Cavum septi pellucidi]	PSEUDOCOELIA	Pseudocele	'81

II. C. Sectiones Prosencephali.

II	Telencephalon	Prosencephalon	Prosencephal	'82
1	Substantia corticalis	CORTEX	Cortex	'81
2	Centrum semiovale	MEDULLA	Medulla	'89; §26
3	Decursus fibrarum cerebralium	?		
4	Fibrae arcuatae cerebri	?		
5	Cingulum	Cingulum	Cingulum	
6	Fasciculus longitudinalis inferior	Fasciculus dorsalis	Dorsal fasciculus	
7	Fasciculus longitudinalis superior	Fasciculus ventralis	Ventral fasciculus	
8	Fasciculus uncinatus	Fasciculus uncinatus	Uncinate fasciculus	
9	Radiatio corporis callosi	Radiatio callosi	Callosal radiation	

II	Telencephalon	Prosencephal	Prosencephal	'81
10	Pars frontalis	Radiatio frontalis	Frontal radiation	
11	Pars parietalis	Radiatio parietalis	Parietal radiation	
12	Pars temporalis	Radiatio temporalis	Temporal radiation	
13	Pars occipitalis	Radiatio occipitalis	Occipital radiation	
14	Tapetum	Tapetum	Tapetum	General
15	Nucleus lentiformis	LENTICULA	Lenticula	'89; §19
16	Putamen	PUTAMEN	Putamen	General
17	Globus pallidus	Pallidum	Pallidum	'96
18	Claustrum	CLAUSTRUM	Claustrum	General
19	Capsula externa	?	?	
20	Capsula interna	Capsula	Capsula	'89
21	Genu capsulae internae	Genu	Genu	
22	Pars frontalis capsulae internae	Pars frontalis	Frontal part	
23	Pars occipitalis c. i.	Pars occipitalis	Occipital part	
24	Nucleus amygdalae	Amygdala	Amygdala	'85
25	Corona radiata	CORONA	Corona	'89
26	Pars frontalis	Pars frontalis	Frontal part	
27	Pars parietalis	Pars parietalis	Parietal part	
28	Pars temporalis	Pars temporalis	Temporal part	
29	Pars occipitalis	Pars occipitalis	Occipital part	
30	Radiatio corporis striata	Radiatio striatalis	Striatal radiation	
31	Radiatio occipitothalamica [Gratioleti]	Radiatio thalamica	Thalamic radiation	
32	Commissura anterior [cerebri]	PRAECOMMISSURA	Precommissure	'81
33	Pars anterior	(see I, 18)		
34	Pars posterior	Pars temporalis	Temporal portion	

III	Diencephalon et Thalamencephalon	Diencephalon	Diencephal	'81
1	Thalamus	THALAMUS	Thalamus	'80, G. N.
2	Pulvinar	PULVINAR	Pulvinar	General
3	Tuberculum anterius thalami	Tuberculum thalami	Thalamic tubercle	
4	Taenia thalami	RIPA	Ripa	'81; §240
5	Stria medullaris	Stria medullaris	Medullary stria	
6	Lamina chorioidea epithelialis	Pars marginalis diatelae?	Marginal part of diatela (needless)	
7	Metathalamus		(Needless)	
8	Corpus geniculatum mediale	POSTGENICULUM	Postgeniculum	'89
9	Corpus geniculatum laterale	PRAEGENICULUM	Pregeniculum	'89
10	Epithalamus		(Needless)	'96
11	Corpus pineale	EPIPHYSIS	Epiphysis	'95; §68
12	Recessus pinealis	Recessus epiphysialis	Epiphysial recess	
13	Recessus suprapinealis	Saccus dorsalis	Dorsal sack	'96, *d*

III	Diencephalon et Thalamencephalon	Diencephalon	Diencephal	'81
14	Habenula	HABENA	Habena	'81
15	Commissura habenularum	SUPRACOMMISSURA (H. F. Osborn)	Supracommissure	'86
16	Trigonum habenulae	Trigonum habenae	Habenal trigon	'96
17	Hypothalamus		(Needless)	
18	Pars mamillaris hypothalami		(Needless)	
19	Corpus mamillare	ALBICANS	Albicans	'81
20	Pars optica hypothalami		(Needless)	
21	Tuber cinereum	Tuber	Tuber	'93
22	Infundibulum	INFUNDIBULUM	Infundibulum	'81, G. N.
23	Hypophysis	HYPOPHYSIS	Hypophysis	'80, G. N.
24	Lobus anterior	Praehypophysis	Prehypophysis	'89
25	Lobus posterior	Posthypophysis	Posthypophysis	'89
26	Tractus opticus	TRACTUS OPTICUS	Optic tract	General
27	Radix medialis	Radix mesalis	Mesal root	'81
28	Radix lateralis	Radix lateralis	Lateral root	'81
29	Chiasma opticum	CHIASMA	Chiasma	'80, N.
30	Lamina terminalis	TERMA	Terma	'81

III. B. Cavitas Diencephali

III	Diencephalon et Thalamencephalon	Diencephalon	Diencephal	'81
1	Ventriculus tertius	DIACOELIA	Diacele	'81
2	Aditus ad aquaeductum cerebri		(Needless)	
3	Commissura posterior [cerebri]	POSTCOMMISSURA	Postcommissure	'81
4	Foramen interventriculare [Monroi]	(Vide Prosencephalon B, 2)	(See Prosencephal B, 2)	
5	Sulcus hypothalamicus [Monroi]	Aulix	Aulix (§195)	'84
6	Massa intermedia	MEDICOMMISSURA	Medicommissure	'80
7	Recessus opticus	RECESSUS OPTICUS	Optic recess	'82
8	Recessus infundibuli	RECESSUS INFUNDIBULI	Infundibular recess	
9	Commissura anterior [cerebri]	(Vide Prosencephalon C, 32)	(See Prosencephal C, 32)	
10	Recessus triangularis	Recessus aulae	Aulic recess (See Prosen, B, 2; §240	'81

III. C. Sectiones Diencephali

III	Diencephalon et Thalamencephalon	Diencephalon	Diencephal	'81
11	Stratum zonale			
12	Nucleus anterior thalami			
13	N. medialis thalami			
14	N. lateralis thalami			
15	Laminae medullares thalami			
16	Nucleus corporis geniculati medialis			
17	N. c. g lateralis			
18	N habenulae	Nidus habenae	Habenal nidus	
19	Fasciculus retroflexus [Meynerti]	Fasciculus retroflexus	Fasciculus retroflexus	
20	Nucleus hypothalamicus [Corpus Luysi]			
21	Pars grisea hypothalami			
22	Commissura superior [Meynerti]			
23	Commissura inferior [Guddeni]	Infracommissura	Infracommissure	
24	Nuclei corporis mamillaris	Nidi albicantiae	Albicantial nidi	
25	Fasciculus thalamomamillaris [Vicq d' Azyri]			
26	Fasciculi pedunculomamillaris			
27	Pars tegmentalis			
28	Pars basilaris			
29	Ansa peduncularis			
30	Pedunculus thalami inferior			
31	Ansa lenticularis			

IV	Mesencephalon	Mesencephalon	Mesencephal	'81, Gen'l
1	Aquaeductus cerebri [Sylvii]	MESOCOELIA	Mesocele	'81
2	Basis pedunculi	CRUSTA	Crusta	'89
3	Brachium quadrigeminum inferius	POSTBRACHIUM	Postbrachium	'89
4	Brachium quadrigeminum superius	PRAEBRACHIUM	Prebrachium	'89
5	Colliculus inferior	POSTGEMINUM	Postgeminum	'89
6	Colliculus superior	PRAEGEMINUM	Pregeminum	'89
7	Corpora quadrigemina	QUADRIGEMINUM	Quadrigeminum	'89
8	Decussatio brachii conjunctivi	Decussatio brachii	Brachial decussation	
9	Decussationes tegmentorum	Decussationes tegmentorum	Tegmental decussations	
10	Fasciculus longitudinalis medialis	Fasciculus longitudinalis	Longitudinal fasciculus	

IV	**Mesencephalon**	**Mesencephalon**	**Mesencephal**	**'81, Gen'l**
11	Formatio reticularis	Reticula	Reticula	
12	Fossa interpeduncularis [Tarini]	FOSSA INTERCRURALIS	Intercrural fossa	'89
13	Lamina quadrigemina			
14	Lemniscus lateralis	Lemniscus lateralis	Lateral lemniscus	'89, G. N.
15	Lemniscus medialis	Lemniscus mesalis	Mesal lemniscus	
16	Nucleus colliculi inferioris			
17	Nucleus nervi oculomotorii	Nidus oculomotorius	Oculomotor nidus	
18	Nucleus radicis descendentis n. trigemini			
19	Nucleus ruber	RUBRUM	Rubrum	
20	Nuclei tegmenti	Nidi tegmenti	Tegmental nidi	
21	Pedunculus cerebri	CRUS	Crus (§196)	'81; §241
22	Radix descendens n. trigemini			
23	Recessus anterior [of 12]	Recessus postcribralis	Postcribral recess	
24	Recessus posterior	Recessus praepontilis	Prepontile recess	'81
25	Stratum album profundum			
26	Stratum griseum centrale	Entocinerea	Entocinerea	'89
27	Stratum griseum colliculi superioris	CAPPA	Cappa	'89
28	Stratum zonale			
29	Substantia nigra	INTERCALATUM	Intercalatum	'89; §241.
30	Substantia perforata posterior	POSTCRIBRUM	Postcribrum	'89
31	Sulcus lateralis	Sulcus lateralis	Lateral sulcus	'89
32	Sulcus n. oculomotorii	Sulcus oculomotorius	Oculomotor sulcus	'89
33	Tegmentum.	TEGMENTUM	Tegmentum	'89, G. N.
34	[Tractus pedunculi transversus]	CIMBIA	Cimbia	'81
35	Velum medullare ant.	VALVULA	Valvula	'81
36	Frenulum veli med. ant	FRENULUM	Frenulum	'89; §241

V	**Metencephalon**	**Epencephalon**	**Epencephal**	**'81**
1	[Pars metencephalica ventriculi quarti]	Epicoelia	Epicele	'81
2	[Pars metencephalica medullae oblongatae]	Praeoblongata	Preoblongata	'85
3	Cerebellum	CEREBELLUM	Cerebellum	General
4	Sulci cerebelli	Sulci et rimulae	Sulci and rimulas	'89; §241
5	Gyri cerebelli	FOLIA	Foliums	'89
6	Vallecula cerebelli	VALLIS	Vallis	'96
7	Incisura cerebelli posterior			

V	**Metencephalon**	**Epencephalon**	**Epencephal**	**'81**
8	Sulcus horizontalis cerebelli	Sulcus peduncularis	Peduncular sulcus	'89
9	Fissura transversa cerebelli	?	?	
10	Vermis	VERMIS	Vermis	'81, G. N.
11	Lingula cerebelli	LINGULA	Lingula	'82
12	Vincula lingulae cerebelli	Folia	Foliums §241	
13	Lobus centralis			
14	Monticulus	MONTICULUS	Monticulus	'89, G. N.
15	Culmen	CULMEN	Culmen	'89
16	Declive	DECLIVE	Declive	'89
17	Folium vermis			
18	Tuber vermis	Tuber	Tuber	'89
19	Pyramis [vermis]	Pyramis	Pyramid	'89
20	Uvula [vermis]	UVULA	Uvula	'89
21	Nodulus	NODULUS	Nodulus	'89
22	Hemisphaerium cerebelli	Pileum (B. B. Stroud)	Pileum; §241	'95
23	[Sulcus praeclivalis	Sulcus furcalis	Furcal sulcus	§241
24	Ala lobuli centralis			
25	Lobulus quadrangularis	Lobus quadrangularis	Quadrangular lobe	'89
26	Pars anterior	Pars cephalica	Cephalic part	
27	Pars posterior	Pars caudalis	Caudal part	
28	Lobulus semilunaris superior	Lobus praesemilunaris	Presemilunar lobe	'89
29	Lobulus semilunaris inferior	Lobus postsemilunaris	Postsemilunar lobe	'89
30	Lobulus biventer	Lobus cuneiformis	Cuneiform lobe	'89
31	[Lobulus gracilis]	Lobus gracilis	Slender lobe	'89
32	Flocculus	FLOCCULUS	Flocculus	'89
33	Flocculi secundarii	Paraflocculus	Paraflocculus	'94
34	" "	Supraflocculus	Supraflocculus	'94
35	" "	Mediflocculus	Mediflocculus	'94
36	Pedunculus flocculi	?		
37	Nidus avis	?	§241	
38	[Folium cacuminis]	Cacumen	Cacumen	'89
39	?	POSTPEDUNCULUS	Postpeduncle	'82
40	Brachium conjunctivum cerebelli	PRAEPEDUNCULUS	Prepeduncle	'82; §241
41	[Fossa praepeduncularis]	Fossa praepeduncularis	Prepeduncular fossa	'89
42	Fastigium	FASTIGIUM	Fastigium	'89
43	Pons [Varoli]	PONS	Pons	'80, A. G. N. S.
44	Sulcus basilaris	SULCUS BASILARIS	Basilar sulcus	
45	Fasciculus obliquus pontis	Fasciculus obliquus	Oblique fascicle	
46	Fila lateralia pontis	?		
47	Brachium pontis	MEDIPEDUNCULUS	Medipeduncle	'81; §198

V. B. Sectiones Pontis et Cerebelli.

V	Metencephalon	Epencephalon	Epencephal	'81
1	Pars dorsalis pontis			
2	Raphe	Rhaphe	Rhaphe	
3	Nucleus n. abducentis	Nidus abducentis	Abducent nidus	
4	Nuclei motorii n. trigemini			
5	Radix descendens [mesencephalica] n. trigemini			
6	Tractus spinalis n. trigemini			
7	Nucleus tractus spinalis n. trigemini			
8	Nucleus n. facialis	Nidus facialis	Facial nidus	
9	Radix n. facialis	Radix n. facialis	Root of the facial nerve	
10	Pars prima			
11	Genu [internum]			
12	Pars secunda			
13	Nuclei n. acustici	Nidi acustici	Acoustic nidi	
14	Nuclei n. cochlearis	Nidi n. cochlearis	Cochlear nidi	
15	Nuclei n. vestibularis	Nidi n. vestibularis	Vestibular nidi	
16	Nucleus olivaris superior			
17	Nucleus lemnisci lateralis			
18	Fasciculus longitudinalis medialis	Fasciculus longitudinalis	Longitudinal fasciculus	
19	Formatio reticularis			
20	Corpus trapezoideum	TRAPEZIUM	Trapezium	'81; §19
21	Lemniscus	LEMNISCUS	Lemniscus	'89, G. N
22	L. medialis sensitivus			
23	L. lateralis acusticus			
24	Pars basilaris pontis			
25	Fibrae pontis profundae	Fibrae pontis entales	Ental fibers of the pons	
26	Fasciculi longitudinales [pyramidales]			
27	Nuclei pontis	Nidi pontis	Pontile nidi	
28	Fibrae pontis superficialis	Fibrae pontis ectales	Ectal fibers of the pons	
29	Corpus medullare	Medulla	Medulla	'89
30	Laminae medullares	Laminae medullares	Medullary laminae	
31	Arbor vitae	ARBOR	Arbor	'89
32	[Ramus posterior]	Postramus	Postramus	'89
33	[Ramus anterior]	Praeramus	Preramus	'89
34	Substantia corticalis	CORTEX	Cortex	'82
35	[Lamina basalis]	[35, 36 and 37 are bracketed in the German list]		
36	[Stratum cinereum]			
37	[Stratum gangliosum]			
38	Stratum granulosum			
39	Nucleus dentatus	DENTATUM (§123)	Dentatum	'89, N.
40	Nucleus fastigii	Fastigatum	Fastigatum	'89
41	Nucleus emboliformis	Embolus	Embolus	'89; §19
42	Nucleus globuliformis	Globulus	Globulus	'89

VI	Myelencephalon	Metencephalon	Metencephal	'80
1	Ventriculus quartus [cavitas communis myelencephali et metencephali]	Metepicoelia	Metepicele	'86; §242
2	Fossa rhomboidea			
3	Pars inferior fossae rhomboideae [calamus scriptorius]	Calamus	Calamus	'82
4	Pars intermedia f. r.			
5	Pars superior f. r.			
6	Sulcus limitans f. r.	Sulcus interzonalis (?)	Interzonal sulcus §195	
7	Fovea inferior			
8	Fovea superior			
9	Trigonum n. hypoglossi			
10	Striae medullares	Striae acusticae	Acoustic striae	
11	Eminentia medialis			
12	Colliculus facialis	Lophius facialis	Facial lophius	
13	Ala cinerea	Ala cinerea		
14	Area acustica	Area acustica		
15	Locus caeruleus	Locus caeruleus		
16	[Hordea]	Hordea [Spitzka]	Hordeums	
17	Tegmen ventriculi quarti			
18	Velum medullare posterius	Kilos	Kilos	§242
19	Taenia ventriculi quarti	Ligula	Ligula	'89; §239
20	Obex	OBEX	Obex	'89; §242
21	Lamina chorioidea epithelialis	Pars marginalis metatelae	(Needless)	
22	(Apertura medialis ventriculi quarti [Foramen Magendii])	METAPORUS	Metapore	'89; '93, c
23	(Apertura lateralis ventriculi quarti)		(Existence doubted)	'93, c
24	Fastigium	(See V, 42)		
25	Medulla oblongata	Postoblongata	Postoblongata	'85
26	[Pars myelencephalica ventriculi quarti]	METACOELIA	Metacele	'81
27	Fissura mediana posterior	SULCUS DORSALIS	Dorsal sulcus	§132
28	F. mediana anterior	S. VENTRALIS	Ventral sulcus	
29	Foramen caecum	Recessus postpontilis	Postpontile recess	'81
30	Pyramis [medullae oblongatae]	PYRAMIS	Pyramid	'81
31	Decussatio pyramidum	Decussatio pyramidum	Pyramidal decussation	General
32	Sulcus lateralis anterior	Sulcus ventrolateralis	Ventrolateral sulcus	
33	S. lateralis posterior	S. dorsolateralis	Dorsolateral sulcus	
34	Oliva	OLIVA	Oliva	'86, G. N.
35	Corpus restiforme	RESTIS	Restis	'89; §19
36	Funiculus lateralis	Funiculus lateralis	Lateral funiculus	
37	Funiculus cuneatus	Funiculus cuneatus	Cuneate funiculus	

VI	Myelencephalon	Metencephalon	Metencephal	'80
38	Tuberculum cinereum	Tuberculum cinereum	Cinereal tubercle	
39	Funiculus gracilis	Funiculus gracilis	Slender funiculus	
40	Clava	CLAVA	Clava	'81, G. N.
41	Fibrae arcuatae externae	Fibrae arcuatae ectales	Ectal arched fibers	

VI. B. Sectiones Postoblongatae.

VI	Myelencephalon	Metencephalon	Metencephal	'80
1	Raphe	Rhaphe	Rhaphe	(§242)
2	Stratum nucleare	Stratum nidale	Nidal stratum	
3	Nucleus n. hypoglossi	Nidus hypoglossi	Hypoglossal nidus	
4	Nucleus ambiguus			
5	Nucleus alae cinereae			
6	Tractus solitarius			
7	Nucleus tracti solitarii			
8	Tractus spinalis n. trigemini			
9	Nucleus tractus spinalis n. trigemini			
10	Nucleus funiculi gracilis			
11	Nucleus funiculi cuneati			
12	Nuclei laterales			
13	Nucleus olivaris inferior			
14	Nucleus olivaris accessorius medialis			
15	Nucleus olivaris accessorius dorsalis			
16	Nuclei arcuati			
17	Fibrae arcuatae internae	Fibrae arcuatae entales	Ental arched fibers	
18	Substantia reticularis grisea			
19	Substantia reticularis alba			
20	Fasiculus longitudinalis medialis	Fasciculus longitudinalis	Longitudinal fasciculus	
21	Stratum interolivare lemnisci			
22	Decussatio lemniscorum			
23	Corpus restiforme	RESTIS	Restis	'89; §19
24	Fasciculi corporis restiformis			
25	Fibrae cerebelloölivares			
26	Fasiculi pyramidales			
27	Fibrae arcuatae externae	Fibrae arcuatae ectales	Ectal arched fibers	

VII	Medulla spinalis	Myelon	Myel	'81; §51
1	Pars cervicalis	Myelon cervicale	Cervical myel	
2	Intumescentia cervicalis	Intumescentia cervicalis	Cervical enlargement	
3	Pars thoracalis	Myelon thoracale	Thoracic myel	
4	Pars lumbalis	Myelon lumbale	Lumbar myel	
5	Intumescentia lumbalis	Intumescentia lumbalis	Lumbar enlargement	
6	Conus medullaris	CONUS	Conus	
7	Filum terminale	FILUM	Filum	
8	Ventriculus terminalis	RHOMBOCOELIA	Rhombocele	'85
9	Fissura mediana anterior	SULCUS VENTRALIS	Ventral sulcus	
10	Sulcus medianus posterior	SULCUS DORSALIS	Dorsal sulcus	§132
11	Sulcus lateralis anterior	Sulcus ventrolateralis	Ventrolateral sulcus	
12	Sulcus lateralis posterior	Sulcus dorsolateralis	Dorsolateral sulcus	
13	Sulcus intermedius anterior	Sulcus intermedius ventralis	Intermediate ventral sulcus	
14	Funiculi medullae spinalis	Columnae *sive* funes *s.* funiculi myeli	Myelic columns or funes or funiculi	'81; §130
15	Funiculus anterior	Columna ventralis	Ventral column	§132
16	Funiculus lateralis	Columna lateralis	Lateral column	
17	Funiculus posterior	Columna dorsalis	Dorsal column	

VII. B. Sectiones Myeli.

VII	Medulla spinalis	Myelon	Myel	'81; §51
1	Canalis centralis	MYELOCOELIA	Myelocele	'85
2	Substantia grisea centralis	ENTOCINEREA	Entocinerea	'89
3	Commissura anterior alba	Commissura ventralis alba	White ventral commissure	
4	Commissura anterior grisea	Commissura ventralis cinerea	Gray ventral commissure	
5	Commissura posterior	Commissura dorsalis	Dorsal commissure	
6	Columnae griseae	Cornua cinerea *sive* columnae cinereae	Gray cornua or columns	'81; §128
7	Columna anterior	Cornu ventrale	Ventral cornu	§131
8	Columna lateralis	Cornu laterale	Lateral cornu	
9	Columna posterior	Cornu dorsale	Dorsal cornu	
10	Cervix columnae posterioris			
11	Apex col. post.			
12	Substantia gelatinosa [Rolandi]			
13	Nucleus dorsalis [Stillingi, Clarkii]			
14	Formatio reticularis	Reticula	Reticula	
15	Funiculus anterior	Columna ventralis	Ventral column	§ 130

VII	**Medulla spinalis**	**Myelon**	**Myel**	**'81; §51**
16	Fasciculus cerebrospinalis anterior [pyramidalis anterior]			
17	Fasciculus anterior proprius [Flechsigi]			
18	Funiculus lateralis	Columna lateralis	Lateral column	§130
19	Fasciculus cerebrospinalis lateralis [pyramidalis lateralis]			
20	Fasciculus cerebellospinalis			
21	Fasciculus anterolateralis superficialis [Gowersi]			
22	Fasciculus lateralis proprius [Flechsigi]			
23	Funiculus posterior	Columna dorsalis	Dorsal column	§130
24	Fasciculus gracilis [Golli]			
25	Fasciculus cuneatus [Burdachi]			

VIII		**Meninges**		
1	Dura mater encephali	DURA	Dura (§116)	'80; N.
2	Falx cerebri	FALX	Falx (§124)	'89; N.
3	Tentorium cerebelli	TENTORIUM	Tentorium	N.
4	Falx cerebelli	FALCULA	Falcula	
5	Diaphragma sellae			
6	Foramen diaphragmatis sellae			
7	Incisura tentorii	Incisura tentorii	Tentorial incision	
8	Dura mater spinalis	Dura spinalis	Spinal dura	
9	Filum durae matris spinalis	Filum durae	Dural filum	
10	Cavum epidurale	Cavum epidurale	Epidural cavity	§118
11	Cavum subdurale	Cavum subdurale	Subdural cavity	
12	Arachnoidea encephali	ARACHNOIDEA	Arachnoid	'80; §118
13	Cavum subarachnoidale	Cavum subarachnoidale	Subarachnoid cavity	
14	Cisternae subarachnoidealae	Cisternae	Cisterns	
15	Cisterna cerebello-medullaris	Postcisterna *s.* c. cerebellaris	Postcisterna or cerebellar cistern	'89
16	Cisterna fossae lateralis cerebri (Sylvii)	Cisterna Sylviana	Sylvian cistern	
17	Cisterna chiasmatis	Cisterna chiasmatis	Chiasmatic cistern	
18	Cisterna interpeduncularis	Cisterna cruralis	Crural cistern	§196

VIII		Meninges		
19	Cisterna venae magnae cerebri	Medicisterna	Medicisterna	'89
20	Granulationes arachnoideales [Pacchioni]			
21	[Leptomeninges]	Piarachnoidea	Piarachnoid	'89
22	Pia mater spinalis	Pia spinalis	Spinal pia	
23	Ligamentum denticulatum	Ligamentum denticulatum	Denticulated ligament	
24	Septum cervicale intermedium			
25	Pia mater encephali	PIA	Pia (§117)	'80; N.
26	Tela chorioidea ventriculi quarti	METATELA	Metatela	'81
27	Plexus chorioideus ventriculi quarti	METAPLEXUS	Metaplexus	'81
28	Tela chorioidea ventriculi tertii	DIATELA	Diatela	Table IV
29	Plexus chorioideus ventriculi tertii	Diaplexus	Diaplexus	
30	Plexus chorioideus ventriculi lateralis	PARAPLEXUS	Paraplexus	'89
31	Glomus chorioideum	Glomus	Glomus	
32	Acervulus	Acervus	Acervus	
33	[Plexus chorioideus telencephali]	PROSOPLEXUS	Prosoplexus	
34	[Tela foraminis interventricularis]	AULATELA	Aulatela	
35	[Plexus chorioideus foraminis interventricularis]	AULIPLEXUS PORTIPLEXUS	Auliplexus Portiplexus	'81
36	[Lamina chorioidea epithelialis (II, 16)]	PARATELA	Paratela	'89

IX. Principal Entocranial Bloodvessels; §242

A. Intrinsic Encephalic Arteries.

1	Basilaris	BASILARIS	Basilar	General
2	Cerebelli inferior anterior	MEDICEREBELLARIS	Medicerebellar	'85
3	Cerebelli inferior posterior	POSTCEREBELLARIS	Postcerebellar	'85
4	Cerebelli superior	PRAECEREBELLARIS	Precerebellar	§147
5	Cerebri anterior	PRAECEREBRALIS	Precerebral	'85
6	Cerebri media	MEDICEREBRALIS	Medicerebral	'85
7	Cerebri posterior	POSTCEREBRALIS	Postcerebral	'85
8	Cerebri anterior media	TERMATICA	Termatic	'85
9	Circulus arteriosus [Willisi]	Circulus	Circulus	
10	Communicans anterior	PRAECOMMUNICANS	Precommunicant	'85
11	Communicans posterior	POSTCOMMUNICANS	Postcommunicant	'85

A. Intrinsic Encephalic Arteries.

12	Chorioidea anterior	PRAECHOROIDEA	Prechoroid	'85
13	Chorioidea	POSTCHOROIDEA	Postchoroid	'85
14	Perforantes anteriores	PRAECRIBRALES	Precribral	'85
15	Perforantes posteriores	POSTCRIBRALES	Postcribral	'85
16	Spinalis anterior	SPINALIS VENTRALIS	Ventral spinal	
17	Spinalis posterior	SPINALIS DORSALIS	Dorsal spinal	
18	Ramus meningeus	Ramus meningeus	Meningeal ramus	
19	Vertebralis	VERTEBRALIS	Vertebral	General
20	Rami spinales	Rami spinales	Spinal rami	

B. Dural Arteries.

1	Meningea anterior	PRAEDURALIS	Predural	'89
2	Meningea posterior	POSTDURALIS	Postdural	
3	Meningea media	MEDIDURALIS	Medidural	
4	Meningea parva	Parviduralis	Parvidural	
5	Meningea inferior	Subduralis	Subdural	

C. Sinuses.

1	Transversus	Lateralis	Lateral	
2	Sagittalis superior	Longitudinalis	Longitudinal	
3	Sagittalis inferior	FALCIALIS	Falcial	
4	Rectus	TENTORII	Tentorial	
5	Petrosus inferior	Subpetrosus	Subpetrosal	
6	Petrosus superior	Superpetrosus	Superpetrosal	
7	Sphenoparietalis	Sphenoparietalis	Sphenoparietal	
8	Confluens sinuum	Torcular	Torcular	

D. Encephalic Veins.

1	Cerebri superiores	Supercerebrales	Supercerebral	'89
2	Cerebri media	Medicerebralis	Medicerebral	
3	Cerebri inferiores	Subcerebrales	Subcerebral	
4	Cerebelli superiores	Supercerebellares	Supercerebellar	
5	Cerebelli inferiores	Subcerebellares	Subcerebellar	
6	Cerebri internae	Velares	Velar	
7	Cerebri magna [Galeni]	Magna (?)		
8	Septi pellucidi	Septalis	Septal	
9	Terminalis	?		
10	Basalis [Rosenthali]	Basalis		
11	Chorioidea	Choroidea	Choroid	
12	Opthalmomeningea	?		

NOTE.—To save space the substantive elements of the vasal dionyms (*arteria*, *vena*, *sinus*) are omitted.

Comments upon Table VI.

§239. *General.*—Professor Kölliker has characterized ('96, 814; §208) "the anatomic nomenclature coming from America in recent years as a complete failure." Professor His has declared ('95, 6, 7; §170) that the writer's "proposals tend to create a language entirely new and for the most part quite strange, and on this ground our commission cannot follow him without renouncing its historic principles."[1] As a main basis of this conclusion, he imputes to me either (according to the intended sense of "verlangen lauter Mononyme") a strong desire for mononyms, or a demand for them to the exclusion of all polyonyms. Since the foregoing extracts might well indicate the existence of a divergence, wide, radical and irreconcilable, between the neural terminology preferred by me and that recommended by the Gesellschaft, attention is asked to the following statistics:

(*a*) Among the (about) 540 terms on the German list there are about 100 concerning which I refrain from expressing an opinion; my doubts are indicated sometimes by blanks in the second column, and sometimes by interrogation points.

(*b*) Among the (say) 440 remaining, the following are so commonly employed that I claim no especial credit for having adopted many of them so long ago as 1880 or 1881:—*Nervus, ganglion, ramus communicans, ramus anastomoticus, nervus cutaneus, nervus muscularis, plexus nervorum spinalium, lobi cerebri* (*frontalis, parietalis, occipitalis et temporalis*), *eminentia collateralis, fornix, tapetum, putamen, claustrum, pulvinar, tractus opticus, mesencephalon, cerebellum, decussatio pyramidum.*

(*c*) Among the (say) 420 remaining, respecting at least 105 (about one-fourth) there is complete, or practically complete, concordance between the German committee and myself; of these, several were adopted between 1880 and 1882, and nearly all prior to the report of the German committee.

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[1] Is it permissible to entertain the hypothesis that not the least operative of these deterrent "historic principles" are an indifference to what is done in America, and an indisposition to recognize value therein?

(*d*) Among the remainder (say 315), about 25, viz., *praecribrum, postcribrum, vadum, aula, porta, ripa, copula, crista, carina, terma, cimbia, folium, pileum, metaporus* and the compounds of *coelia*, may be regarded as unfamiliar.

(*e*) But with most of the others the differences from the German equivalents may be indicated by the following examples:—Calcar (for *calcar avis*), callosum (for *corpus callosum*), dura (for *dura mater*), postcornu (for *cornu posterius*), praecommissura (for *commissura anterior*), gyrus subfrontalis (for *gyrus frontalis inferior*), medipedunculus (for *brachium pontis*), habena (for *habenula*), trapezium (for *corpus trapezoides*), radix dorsalis (for *radix posterior*), diaplexus (for *plexus chorioideus ventriculi tertii*); see Part IV.

(*f*) Finally, the German list contains at least forty mononyms, while in my own list of about 440, at least 270, more than one half, are polyonyms; see §242, IX.

§240. *Special.*—In the division "Termini Neurologici Generales", in the sixth line, the term *Taenia telarum* of the German list is made equivalent to my *Ripa*. A similar equivalency is indicated in II, B, 15 and 23; and in III, 4. In respect to these, and also the interpretations implied in II, B, 13; III, 5; and VI, 19, I wish to make further observations. I was early ('81, *d*) impressed with the morphologic significance of these marginal parts or "shore-lines" of the encephalic cavities, but now that the foregoing list is printed I am disposed to think that in my recent revision sufficient attention was not paid to the diagrams and suggestions of Prof. His ('95, 165-168). If his views prove to be correct I shall be pleased, since upon some other points I have found myself unable to agree with him. Upon these and upon any other features of the Table and of the entire paper I desire criticism and suggestions from all who may interested.

II, 17, *Fissura Sylvii.*—In advocating the retention of this, while objecting to eponyms in general since 1880, I am certainly open to the charge of inconsistency. The following points should be borne in mind:—(1) Little personality or nationality attaches to this name. (2) There are exceptions to most rules (§260). (3) Even if my *basisylvian*, *presylvian* and *subsylvian* be rejected as titles of human fissures, there are several fissures in animal brains that have for many years been known by "sylvian" compounds. (4) The substitute proposed by the German committee, *cerebri lateralis*, is rather general than specific in suggestion. (5) If they are right in regarding the fissure as collocated with the striatum (His, '95, 170), then, after the fashion of *hippocampal*, *calcarine* and *collateral*, the more appropriate term would be *Fissura striatalis*.

II, 74, 75, *Gyrus subcollateralis* and *G. subcalcarinus.*—So slight is the resemblance of these cortical strips to the forms indicated in the commonly accepted *simile* names, *fusiformis* and *lingualis*, that I have never been able to remember their relative locations. It seems probable that the fissural names *calcarina* and *collateralis* are to persist. If so, is it not both logical and convenient to designate the gyres just ventrad of them by locatives indicating their positions, viz., *G. subcalcarinus* and *G. subcollateralis* ?

II, 85, *Sulcus interparietalis.*—Prof. Sir William Turner originally named the fissure *intraparietalis*, and the same form is employed in his last fissure paper (*Jour. Anat. and Phys.*, Oct., 1890). To more essential grounds for doubting the advisability of applying any name to this "fissure complex," must be added the carelessness of printers and proof-readers, and even the apparent ignorance of some writers as to the distinction between *inter* and *intra*.

II, B, 2, and III, B, 10, *Recessus aulae.*—I may err in supposing the *recessus triangularis* of the German list to be identical with the *recessus aulae* described by me in 1881 ('81, *d*).

II, B, 4, *Paracoelia.*—Even were there not adequate reasons for replacing *ventriculus* in all neural names by *coelia*, *paracoelia* is simply the Greek equivalent of *ventriculus lateralis*, and as such has equal privileges with the German heteronym "*Seitenhöhle*" which has been used heretofore and will hardly disappear at once.

II, B, 18, *Eminentia occipitalis.*—The name preferred by the German committee, *Bulbus cornu posterius*, is bracketed in their list. As I have shown ('84, *a*, 373, and '89, *a*, 143), at a certain fetal stage the occipital fissure has a distinct ental correlative and is hence entitled to be ranked as a total fissure, or, according to the distinction proposed by the German committee, as a fissure rather than a sulcus. But in the adult the general thickening of the walls commonly obliterates the original elevation, and the "totality" of the fissure is not apparent. This temporary existence of the essential character should perhaps constitute a fourth objection to the distinction between *fissura* and *sulcus* proposed by the German committee and discussed in §§121-122.

II, B, 37, *Indusium.*—This seems to have been omitted from the German list. Its condition in man, chimpanzee, monkey, cat and sheep has been discussed by Fish ('93, *a*).

II, C, 1, *Cortex.*—I am unable to see any good reason for replacing this familiar and suggestive mononym by the ponderous dionym, *substantia corticalis.*

II, C, 14, *Tapetum.*—The original Latin is *tapete*, perhaps from the Greek τάπης. The ending *e* occurs with so few anatomic terms, e. g., *rete*, that it is perhaps scarcely worth while to disturb the established modern usage.

II, C, 21-23.—Why should these names of divisions include the genitive of the major part any more than with 10-14, or 26-29?

III, 8, 9, *Postgeniculum* and *Praegeniculum.*—These locative names retain the essential features of the earlier polyonyms. The parts are strictly caudad and cephalad of one another. The more lateral aspect of the praegeniculum is due to a difference in size.

III, B, 4, *Foramen interventriculare.*—This cavity, the aula (§211) and two portas of my list (II, B, 2, 3), connects the right and left "lateral ventricles." These are cavities of the "telencephalon" (my prosencephalon), not of the diencephalon.

III, B, 9, *Praecommissura.*—This is certainly prosencephalic ("telencephalic"), and to include it among diencephalic parts is as artificial as in the case of the "foramen interventriculare" (III, B, 4).

§241. IV, 21, *Crus.*—The fibrous mesencephalic masses are mentioned ten times where the "stems" of the cerebellum or olfactory bulbs are named once; hence the greater need of a brief mononymic designation for the first; for the second and third either the longer *pedunculus* or the addition of a qualifier would prove less burdensome.

IV, 29, *Intercalatum.*—This locative mononym was suggested by Spitzka in 1887; W., '89, *a*, §103.[1]

V, 4, *Sulci cerebelli.*—For most of the interfoliar crevices I proposed *rimula* in 1889. But, as shown by Stroud, certain of them are deep and merit the title of *sulcus.* For the minor crevices *rimula* (or perhaps *sulculus*) may serve.

V, 6, *Vallis.*—For the grounds of preference for the briefer basal word (§30) over the longer diminutive, see W. and G., '89, 529, §75.

V, 12, *Folia* [*lingulae*].—For the diminutive "leaflets" on the lingula no special name seems to be needed, and if it were, *vincula* alone would suffice.

V, 22, *Pileum.*—The substitution of this mononym for *hemisphaerium cerebelli* was proposed by Dr. B. B. Stroud ('94); on developmental grounds he recognizes a *praepileum* and *postpileum.* Stroud's "furcal sulcus" seems to be what is called "preclival" in the last edition of Quain, III, Fig. 59. Other features of the cerebellum described and figured by Stroud (the *cestus* and several sulci, *central, culminal, tuberal, pyramidal, uvular* and *nodular*) are not included in the present list.

V, 37, *Nidus avis.*—The depression thus designated is so seldom mentioned that the dionym is not burdensome. If C. L. Herrick had not proposed *nidulus* for *nucleus* the former might be an acceptable mononym for the little "nest."

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[1] In the German list, between *mesencephalon* and their *metencephalon* (my *epencephalon*), are enumerated nine parts under the head, "Isthmus rhombencephali." Their omission from the present table was accidental, and due to my reversal of the original order of enumeration of the segments. I have already expressed (§197) my objection to the assignment of segmental value to this necklike region, and shall consider it hereafter (§250). *Lemniscus* is included in IV, 14 and 15. *Brachium conjunctivum* [*cerebelli*] probably designates the praepedunculus (V, 40). *Velum medullare anterius* is the valvula (IV, 35). For *ganglion interpedunculare* I prefer *ganglion intercrurale*, and for *Nucleus trochlearis*, *Nidus trochlearis.*

V, B, 36, *Stratum cinereum.*—Why not (in the German list) *stratum griseum,* in accordance with the word employed among the "Termini generales?" see §36.

VI, 1, *Metepicoelia* or "ventriculus quartus."—The division of this continuous cavity into regions corresponding with the two recognized segments (V, 1 and VI, 26) must be considered upon another occasion (§250).

VI, 25, *Medulla oblongata.*—According to the German committee this is coextensive with their myelencephalic segment (my metencephalon), and the ventral portion of the segment next cephalad (their metencephalon, my epencephalon) is constituted by the pons. But the pons exists only in mammals; hence in the other vertebrates the cerebellar "roof" would be unsupported by a "floor;" see V, 2, præoblongata.

VI, 30, *Pyramis.*—The replacement of *corpus pyramidale* and of *processus clavatus* (40) by *pyramis* and *clava* respectively was urged by Spitzka fifteen years ago ('81, *a*).

VI, B, 15, *Nucleus olivaris accessorius dorsalis.*—If *dorsalis* be appropriate here, why not in several other cases where *posterior* is employed by the German committee?

§242. VII, *Myelon.*—Respecting the substitution of this mononym for the dionym *medulla spinalis,* which was proposed by Owen just half a century ago, see §51. Owen also consistently, although I think unwisely, employed the compound, *myelencephalon,* for *axis cerebrospinalis.* Huxley applied it to the last encephalic segment, and this misappropriation is sanctioned by the German committee. Reserving comments upon these points for another occasion (§250), I now claim that the sole justification for the use of *myelencephalon* is the adoption of *myelon* in the Owenian sense.

VIII, 32, *Acervus.*—This word, signifying a heap, occurs in Andrews and Stoddard's lexicon. The diminutive, *acervulus,* is longer, needless and of modern origin.

IX, *Bloodvessels.*—As admitted by me in 1884 ('84, *e*) and restated in §§163 and 172, absolute mononymy is unattainable with large groups of organs, *e. g.*, muscles, fissures and vessels. Hence, excepting with *circulus* (*A*, 9) and *torcular* (*C*, 8), with the single word adjectives in this category must be understood *arteria, sinus* or *vena;* and when there is any danger of ambiguity the substantive or its abbreviation should be employed.

TABLE VII. Provisional Grouping of Some Neural Parts according to their Segments and some other Characters.

	1. Chief constituent	*2. Segment*	*3. Cavity*	*4. Membranous portion*	*5. Plexuses*	*6. Thin and Riparian parts*	*7. Commissures, etc.*	*8. Some other parts*
I	Bulbi olfactorii	Rhinencephalon	Rhinocoelia	Rhinotela (in some "fishes")			Praecommissura (pars olfactoria)	Praecribrum; limen
II	Cerebrum	Prosencephalon	Prosocoelia (including the mesal aula and lateral paracoeliae)	Prosotela (including the mesal aulatela and lateral paratelae)	Prosoplexus (including the mesal auliplexus lateral paraplexus	Taenia; fimbria; pala; terma	Praecommissura (pars temporalis) callosum; fornix	Pallium; insula; lenticula; caudatum; paraphysis
III	Thalami	Diencephalon	Diacoelia	Diatela	Diaplexus	Habena	Supracommissura; medicommissura; chiasma	Postcribrum; tuber; hypophysis; epiphysis; genicula
IV	Quadrigeminum	Mesencephalon	Mesocoelia	Mesotela (in the lamprey)		Valvula	Postcommissura; decussationes tegmentorum	Crus; tegmentum; crusta; lemniscus; intercalatum
V	Cerebellum	Epencephalon	Epicoelia	Epitela	Epiplexus	Lingula	Pons	Praeoblongata; vermis; flocculus; dentatum
VI	Postoblongata	Metencephalon	Metacoelia	Metatela	Metaplexus	Metaporus; ligula; obex	Decussatio pyramidum	Pyramis; oliva; trapezium
VII	Myelon	Myelon	Myelocoelia	Myelotela (in lumbar enlargement of birds.)			Commissura ventralis; c. dorsalis	Conus; filum

Commentaries Upon Table VII.

§243. Its purpose is two-fold:—(*a*) To indicate, according to my present information and belief, the number and constitution of the definitive encephalic segments. (*b*) To illustrate the verbal correlations between the names of the segments themselves (column 2), and those of (3) their major cavities, (4) their membranous parietes, and (5) their vascular plexuses.

§244. It is in some respects an amplification of the table on p. 409 in W. and G., '82. It differs from that in my later paper ('89, *a*, 121) in (*a*) the recognition of the Rhinencephal and (*b*) the vertical arrangement of the segments.

§245. From Schwalbe's table ('81, 397) it differs mainly in the absence of any attempt to indicate the relative "values" of the several segments upon embryologic or other grounds.

§246. In this respect it differs also from that of His ('95, 162). In this latter, moreover, I have not as yet succeeded in recognizing consistency with (*a*) his other table on p. 158, (*b*) the segmental arrangement employed in the German list of neural terms (80-87), (*c*) a discriminating use of terms, (*d*) due regard for precedent, or (*e*) the facts of comparative anatomy as I interpret them.

§247. Conceding the high authority of Professor His as to the embryology of man, I nevertheless believe it to be altogether undesirable to infer the segmental constitution of the vertebrate brain from the conditions presented during the development of the human organ. Indeed, if the embryology of other forms were also taken into account, the number of potential "neuromeres" would be unmanageably large, even if any two investigators could agree at present as to how many should be recognized.

§248. While anticipating that the problems involved will be eventually elucidated upon the basis of all the facts concerned, I believe our present effort should be to agree upon a *schema* of the vertebrate brain which, while not contravening the facts of embryology, shall harmonize so nearly with the facts of comparative anatomy as to facilitate rather than obstruct an effort to describe and interpret the conditions encountered in a given brain.

§249. I freely admit my ignorance or non-comprehension of certain points, and also that my views have varied somewhat, particularly as to the segmental value of the olfactory region of the brain. Nevertheless, I regard myself as justified in advocating the *schema* presented in Table VII upon the following grounds:—(1) For more than twenty years the general question has never been long out of my mind; (2) with special reference to it I have prepared and studied scores of brains of all classes and most of the orders; (3) the subject has been discussed more or less fully in papers by me[1] upon the brains of many different forms; (4) papers upon other forms[2] have been prepared at this institution; (5) the *schema* has proved practically available for research as indicated above, and has been readily comprehended and remembered by even general students.

§250. What I advocate is that there be recognized for the present six definitive segments of the vertebrate brain under the titles Rhinencephalon, Prosencephalon, Diencephalon, Mesencephalon, Epencephalon[3] and Metencephalon. It is my intention to review the whole subject at the coming meeting of the Association of American Anatomists in May, 1897.

Part VIII. Concluding Remarks.

§251. A. *Practical Suggestions.*—As one of the older American anatomists, and as having committed at least my full share of terminologic errors, I venture to formulate some suggestions of a practical nature for the benefit of the younger generation.

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[1] See Bibliography, '75, *c;* '76, *a, b, c;* '77, *a;* '81, *d;* '84, *a, d;* '85, *b;* '87, *a, b, c;* '89, *a;* '91, *b;* '93, *a;* '96, *d*; W. & G., '82, chap. X.

[2] See papers by Clark, Mrs. Gage, Fish, Humphrey, Kingsbury and Stroud.

[3] Even if Osborn is correct in his interpretation of the cerebellum as "primitively" intersegmental ('88, 57) he nevertheless admits that it "secondarily acquires a functional importance equal to that of the other segments."

§252. *Caution in Publishing New Terms.*—It is true that words needlessly introduced into anatomy have no such embarrassing permanency as is conventionally assigned to synonyms in systematic zoology. Nevertheless, for a time at least, they encumber current publications and dictionaries. Hence, however necessary and legitimate they may seem to the framer, neither a new term, nor an old one in a new sense, should be actually published without prolonged consideration, and consultation with at least four individuals representing as many categories of possible critics :—(*a*) an investigator of the same general subject; (*b*) an experienced teacher; (*c*) an earnest student; (*d*) a philologic expert whose admiration for the past has not blinded him to the needs of the present and the future.

§253. *Method of Introduction of New Terms.*—As "urgently recommended" by the A. A. A. S. Committee on Biological Nomenclature (§84), "Whenever a technical word is used for the first time, the author should give in a special note (*a*) the Latin form, (*b*) the etymology, (*c*) the proper adopted form or paronym for his own language, with the adjective, etc., when applicable, (*d*) as concise and precise a definition as possible."

§254. *Indirect Responsibility for Latin Terms.*—Even when the foregoing admirable rule is not followed, the validity of the following can hardly be questioned :—"The introduction of any derivative, oblique case, or national paronym renders the introducer responsible for the actual or potential Latin antecedent of such word in accordance with the usual rules of derivation and paronymy (§178).

§255. *Paronyms versus Heteronyms.*—Excepting with a few conspicuous or particularly important parts, *e. g.*, head, heart, brain, *etc.* (§48), there should be employed either the Latin (international) names, or the national paronyms (§46; Tables II and V). It is quite true that "calling a millstone by a Greek name does not enable us to see a whit farther into it"; yet the designation of parts of the body by terms of classic source, even if somewhat modified in form, enables the anatomists of other nationalities to apprehend the signification more readily than they might from vernacular words.

§256. *Homonyms.*—As has been repeatedly observed (§§23, 26, 68, etc.) the context commonly averts misapprehension as to words having two or more meanings. The probability of confounding the mouth with a bone is scarcely greater than that of mistaking a mathematic for a urinary calculus. But when a term or phrase possibly ambiguous is first introduced in a given publication, and especially in the title, absolute explicitness should be attained, no matter how many qualifying words may be required. In the title of a paper, the term "cervical follicles" is certainly ambiguous, and while "mental prominence" as employed by Huxley is shown by the context to designate a projection in the region of the chin, in a title it might be readily misunderstood, particularly by a psychologist.[1]

§257. *Consistency.*—This ranks second among the desirable attributes of all scientific writing which I have long called the five C's, viz., Clearness, Consistency, Correctness, Conciseness, and Completeness. The last may seldom be attained; the lack of the first and second is as rarely excusable.[2] The practice of the virtue of Terminologic Consistency is tantamount to avoidance of the vice of Pecilonymy (§§34-39).

§258. *Avoidance of Pecilonomy.*—Whatever doubts a writer may entertain as to the relative excellence, authority or vogue of two or more synonyms, and however he may shrink from committing himself to either one of them (§39), justice to

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[1] The title ("On the fracture system of joints, with remarks on certain great fractures") of a paper just received (*Bost. Soc. Nat. Hist. Proceedings*, XXVII) might at first sight seem to concern the surgeon quite as much as the geologist.

[2] While never really justifiable, obscurity of style may result from conditions more or less difficult to avoid; let us assume that no scientific writer would deliberately formulate the doctrine credited by Jules Janin to Balzac. When asked the meaning of a passage the novelist is reported to have replied "Ceci pour le bourgeois", and to have explained that an unintelligible sentence or phrase now and then had a good effect on the "general reader", who, if the sense were always too obvious, might flatter himself that he was equal to the writer and on a level with his thoughts.

his readers, if not regard for their good opinion, should lead him to make his selection in advance and to adhere thereto throughout a given publication.[1]

§259. *Abbreviational Methods.*—The following rules are recommended.

a. The abbreviation should indicate the Latin (international) name. With all mononyms this will also indicate equally well the national paronym; but with English and German polyonyms (§47), the usual transposition of the adjective and substantive renders the recognition less easy.[2]

b. Abbreviations should be formed regularly, and vowels excluded excepting when the initial letter is such, or when their absence might occasion ambiguity.

c. In the explanation of a figure abbreviations should be set in alphabetic order. So natural, reasonable and just is this rule that its disregard can only be attributed to the selfish assumption upon the part of a writer that the time its observance would have cost him is of more value to the world than the time its non-observance costs all of his readers together, not to mention the ill-effects of righteous indignation.

§260. *Importance of Moderation.*—As with biologic generalizations, there are few philologic rules without exceptions. Yet the reformer, especially if young and enthusiastic, either ignorant of history or undismayed thereby, "too often imagines

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[1] As stated in §55, the principle and method were adopted by me in 1880. At that time Henle's works were not known to me. But in 1884 I was so impressed with his systematic employment of a single set of names that the first step in the collaboration toward Foster's Medical Dictionary (§58) consisted in photographing the "Index" of his "Nervenlehre" and distributing copies for discussion.

[2] From my point of view this constitutes an argument for the conversion of certain polyonyms into mononyms. For example, if the dionym *commissura anterior* be retained, the Latin and French abbreviation would be *c. a.*, the English *a. c.*, and the German *v. c.* But of the mononym, *praecommissura*, *prc.* would probably serve in each case.

that a principle, if right, cannot be carried too far;"[1] (Barclay). In this connection may be appropriately quoted the verse from Horace:

> "*Est modus in rebus; sunt certi denique fines,*
> *Ultra citraque nequit consistere rectum.*"

§261. B. *Suggestions to American Anatomists.*—Circumstances have precluded the possibility of submitting either the manuscript or the proofs of this article to other members of the American committees. Hence their responsibility for its contents must be limited strictly by their official recommendation of certain terms or principles, and by the usages embodied in their individual publications. I hope they will join in whatever discussion of the general subject may be aroused by this article freely and without apprehension that opposition to my views will affect my personal or official relations. All I ask of them is the clear recognition of all the conditions.

§262. Perhaps my own view of what the conditions really are may be most conveniently introduced by a commentary upon a paragraph in the address of the president of the Association of American Anatomists a year ago. Professor Dwight said ('95):

> "German anatomists have recently adopted a report prepared by some of their number working in company with representatives of other European countries. It is for us to consider whether this one can be looked upon as accepted and whether it is acceptable; whether we can join hands with our foreign colleagues, or whether we can devise an American nomenclature which shall be so much better that we can disregard the inconvenience of a distinct standard. We have had for years a committee on Anatomical Nomenclature, with Professor Wilder for secretary, who has given so large a part of his busy life to this matter. We may expect an important contribution to the matter in the report of this committee."

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[1] Illustrations may be found in the record of my own terminologic progress, Part II, in the rigid insistence at various stages upon the indispensability of words in Latin form (1880-1883), and upon idionyms or terms absolutely free from ambiguity (prior to 1895). *Cerebrocortex* and *cerebellocortex* were products of the too general (and yet never sweeping) application of the principle of mononymy.

§263. Dr. Dwight's address was devoted mainly to what he justly characterized as "a social question of the first importance, far transcending purely scientific discussion, *viz.*, the methods of obtaining and utilizing anatomical material." Nomenclature was considered briefly and almost incidentally. The following commentaries are designed partly to reinforce some of his remarks, and partly to avert possible misapprehension as to both what he said and what he felt obliged to omit.

§264. In the first place, as a member of the committee on Nomenclature of the Association of American Anatomists since 1889 (§81), Dr. Dwight recognizes with especial clearness that the subject can no longer be ignored. Now that a score of European anatomists have given more or less attention to it during six years, and have expended upon it about $2500.00, no individual or association can hereafter treat it as insignificant.

§265. Secondly, the approximate completeness of the German list of the visible parts of the entire body renders it a substantial basis for discussion and a starting point for further progress.

§266. The two conditions just named will, as doubtless anticipated by Dr. Dwight, lead anatomic writers and teachers to pay more heed to their terminology, and to maintain at least a temporary consistency, *i. e.*, within the limits of a single lecture, article or treatise.

§267. Yet our gratification at the tardy German admission of the need of terminologic improvement, and our recognition of the usefulness of the list compiled with such learning and industry and at such expense, should not lead us to overlook (*a*) the limitations of the German report in both intent and performance; (*b*) the delay in its adoption by other nations; (*c*) the qualifications of Americans for independent judgment.

§268. The "B. N. A.", *i. e.*, the *Nomina Anatomica* adopted by the Anatomische Gesellschaft at Basel in 1895, is regarded by the Germans themselves as provisional and subject to modification. As stated officially (*Anat. Anzeiger*, Ergänzungsheft, X, 161), and by Prof. His (§§2, 228) there was appointed a standing committee of revision, which is to report upon proposed changes and new terms at intervals of three years.[1]

§269. Although France and Great Britain were represented upon the general committee, no members from those countries were present at the signing of the report and of the declaration against the efforts of the American committees, April 19, 1895 (*Anat. Anz.*, Ergänz., X, 162). Furthermore, as frankly stated by Prof. His ('95, 6-8), some of the French correspondents preferred a different method of procedure, and the English commission had not reported at all (§170). The improbability of universal and unqualified assent upon the part of British anatomists is indicated by the following remarks of a Glasgow professor (Cleland and Mackay, '96, 3):

> "With regard to the naming of individual structures it may be noted that more than one attempt has been made to impose uniformity of nomenclature by the arbitrary authority of an individual or committee.[2] It may be doubted if any such attempt can possibly be successful. The "Nomina Anatomica" of His ('95, *a*) is most important for consultation; but the adoption of its recommendations in this country (Great Britain) would, in a large number of instances, involve the abandonment of good names in general use for others whose advantages are not obvious."

§270. Through its secretary the German committee declared (Krause, '91; §158, 7) that it intended to be "conservative in its action." Now *conservatism* is notoriously difficult to define, and in respect to nomenclature its degrees may equal in number those who have opinions upon the subject. But

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[1] So far as appears in the official record (*Anat. Anz.* XII, Ergänzungsheft, 1896)no reference to nomenclature was made at the last meeting of the Anatomische Gesellschaft. Curiously enough, however, the title of a paper (pp. 153-154) by Bardeleben, who signed the antimononym declaration of the "Nomenclatur Commission" (§147), is "Ueber das Praefrontale und Postfrontale des Menschen". I am not disposed to cite these two words as adjectival locatives and as precedents for *postcava* etc. (§181); but they are excellent mononymic adjectives used as substantives, (§115) and they do not occur in the official list adopted by the committee of which Bardeleben was a member.

[2] No such attempt is known to me. The very notion savors of ecclesiasticism rather than of science. At the most, individuals have set certain fashions, more or less commendable and permanent, while committees have made recommendations which even their own members may disregard when their information is increased or their views are modified.

while the abolition of the vast majority of time-honored terms has not been even hinted at in this country, I believe many anatomists here and also in England have recognized earlier and more fully than most of the Germans the existence of two conditions (§190, F) that are essentially modern, viz., (a) the enormous expansion of anatomic and physiologic knowledge; (b) its general diffusion among the people.[1]

§271. Indeed, notwithstanding the declaration of conservatism above mentioned, it is not easy for me to conceive that all the members of the Anatomische Gesellschaft really anticipate the retention of, *e. g.*, "manubrium sterni," "corpus sterni" and "processus xiphoideus" for *praesternum*, *mesosternum* and *xiphisternum*, respectively; of "squama occipitalis" for (*os*) *supraoccipitale;* of "arcus zygomaticus" for *zygoma;* of "latissimus dorsi," "biceps brachii" and "triceps brachii" for *latissimus*, *biceps* and *triceps* respectively; of "processus vermiformis" for *appendix;* of "substantia corticalis" for *cortex;* of "vena cava superior" and "vena cava inferior", radix anterior" and "radix posterior", for terms not dependent for appropriateness upon the erect attitude of the human body.

§272. In the declaration of the Anatomische Gesellschaft (§147), and in the warning of its oldest member (§208), it is intimated that between the American and German committees there already exists a terminologic crevice which further advance upon our part is likely to convert into an "impassable gulf." Taken by themselves, or in connection with the pass-

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[1] For nearly ten years, at Cornell University, the members of the general classes in physiology, candidates for first degrees in Arts and Science, and numbering from 150 to 180 in each year, have individually examined, drawn and dissected each the brain of a sheep. At the recent meeting of the American Society of Naturalists, I outlined ('96,) a plan for the commencement of practical studies of the brain in primary schools; this in pursuance of the conviction expressed seven years ago:

"Aside from prejudice and lack of practical direction as to removing, preserving, and examining the organ, there is but one valid reason why every child of ten years should not have an accurate and somewhat extended personal acquaintance with the gross anatomy of the mammalian brain; that obstacle is the enormous and unmanageable accumulation of objectionable names under which the parts are literally buried." W. & G., '89, §82.

ages just referred to, it seems to me that Dr. Dwight's closing words convey a similar gloomy impression, and that they present alternatives too widely divergent.

§273. As may be seen from Parts IV and V, with the single exception of the German retention of *anterior* and *posterior* (§§132, 192), between the German committee and the American committees that had reported prior to the three utterances referred to in the last paragraph, the actual differences were simply trivial. Even the list adopted by the American Neurological Association contains no unfamiliar term whatever.[1]

§274. It must be remembered also that only neural terms are here referred to. As well remarked by Pye-Smith ('77, 162) and by His ('95, 155), encephalic nomenclature stands most in need of revision and offers peculiar difficulties. With the other regions of the body the conditions and necessities are far simpler. Hence there is no probability that any action of American committees respecting anatomic nomenclature *as a whole* could eventuate in the establishment of what could be regarded justly as a "separate standard." A stronger phrase for the hypothetic contingency could hardly be employed were the differences between the two sets of names comparable with the distinctions between the metric system and the English weights and measures.

§275. The address of Dr. Dwight contained no reference to what has already been accomplished or proposed by American organizations. At that time, of course, the action of the American Neurological Association had not been taken. But the Association of American Anatomists and the American Association for the Advancement of Science (§§81-85) at various periods between 1889 and 1892, had adopted unanimously the recommendations of their three committees corresponding with the first five sections of the report of the A. N. A. (§80).

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[1] The allegation of Professor His that my individual "proposals tend to create a language entirely new and for the most part quite strange," has already been met (§204). In matters non-scientific a deliberate exaggeration of like extent would probably receive a briefer and less euphemistic characterization.

§276. Although the specific terms included in these recommendations are few, they exemplify all the commendable features of the German report. Indeed, I fail to discover in the latter any general statement, principle, rule or suggestion that had not already been set forth with at least equal accuracy, clearness and force in the writings of British and American anatomists prior to 1895.

§277. Notwithstanding the small number of individual terms included in the American reports, the dates of appointment of the committees, 1885, 1889, 1891, the representative nature of the terms, and the comprehensiveness of the general recommendations, all justify deliberate and independent action upon the part of anatomists in this country. Hence it is gratifying to see Dr. Dwight's indication of our duty in this regard. He evidently advocates neither heedlessness nor a servility that might merit the application of the following caustic comment in an English review of an American work:

> "Our authors are merely following the lead of a certain eminent German anatomist, it being a fashion with American scientific writers (except a few who prefer a sort of scientific Volapük[1]) to follow pretty blindly the German scientific leads in the matter of nomenclature, and this even to the extent of bodily adopting actual German words into a language which can already find two or three synonyms for almost any word it may be desired to translate. No doubt many English authors are also to blame in this respect, but the fact is none the less to be deplored."[2] *Nature*, Aug. 13, 1896, 341.

§278. It seems to me that in America the present conditions are particularly favorable to deliberate thought and independent conclusion upon the subject of this article. The professors of anatomy in some of the larger medical schools are young and vigorous. Few if any are rightly to be reckoned as "old," or at any rate as too old to change their minds and

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[1] Histologic terminology was apparently referred to here; but I imagine that the remark might apply equally to my series of correlated names for one of the encephalic segments and some of its parts, viz., *metencephalon*, *metacoelia*, *metatela*, *metaplexus* and *metaporus*; see Table VII.

[2] The writer of a letter in the *Nation* for Oct. 8, 1896, declares that "there is a reaction setting in in America against extreme Germanization, and that it has not come too soon." For a comparison of the national *Anlage* with the international *proton*, and a citation of Aristotelian precedents for the latter, see §212.

their modes of expression when occasions arise.[1] In view of all the circumstances, the attitude appropriate for American anatomists, desirous to cöoperate yet maintaining their independence and self-respect, is indicated in the following lines of Lucretius :

> *Judicio perpende: et si tibi vera videntur,*
> *Dede manus: aut si falsum est, adcingere contra.*

§279. Those anatomists who are either interested already in the improvement of nomenclature, or whose regard for their successors leads them to sacrifice some present time and effort in their behalf, are urged to read upon the subject, to reflect, to confer, and to correspond freely. So intimate is the relation between verbal expression and mental operation that, even when we imagine ourselves above such weakness, criticism of the former too often means disturbance of the latter. Hence, as with other matters involving individual habit and preference, an actual interview may sometimes be less productive of good than a correspondence that eliminates more completely the personal element and affords opportunity for reflection and for consultation with disinterested experts.[2]

§280. Those who may entertain[3] a not unnatural impatience at the apparently slow progress made in this country, and who may even feel mortified when comparing the two score terms adopted by the American Neurological Association with

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[1] The following incident encourages the belief that such changes of both opinion and custom may occur at any age. While preparing the new edition of his "Anatomy" ('89), Leidy preferred *central lobe* or *island of Reil;* but later, at the age of sixty-six, as chairman of the committee on nomenclature of the Association of American Anatomists, he signed the report recommending *insula.*

[2] Nearly all my letters and "slips" (§78, note) from anatomists and linguists in this and other countries have been preserved. Always instructive and often encouraging, the restraining and even destructive quality of some might have been endured with less equanimity at a personal conference; see §71, and '91, *b.*

[3] That such sentiment, if entertained, has not been communicated to me, either directly or indirectly, constitutes one of the many evidences of the tolerant and helpful spirit that has animated American anatomists in dealing with the confessedly perilous qnestion as to how independent thinkers may best communicate with their fellows.

the forty-five hundred recommended by the Anatomische Gesellschaft, may well consider:

First, the improbability that any competent American anatomist could have been diverted from his regular duties long enough to accomplish what was so effectively done by the secretary of the Anatomische Gesellschaft.

Secondly, the enormous advantage afforded by the complete list adopted by the Gesellschaft. Many dead or dying terms have been disposed of, and the "decks have been cleared" for more efficient action.

Thirdly, whatever precipitation, vacillation, and error may be condoned in individuals whom volition or circumstances may lead to assume untenable positions, organizations legislating in the interest of posterity should advance so slowly as to risk neither recession nor even deflection. The Germans themselves regard their comprehensive list, as a whole, as provisional. The American selections (§§80, 238) constitute, we may believe, an immortal forty.

§281. Were neural terms to be now devised *de novo*, the hippocamp would certainly receive some less fantastic designation, and the great cerebral commissure would be much more likely to be called *trabs* (a beam) than *corpus callosum*. But both *callosum* and *hippocampus* are embalmed, as it were, in several other names and they are not sufficiently objectionable to warrant their revolutionary annihilation. The best we can do is to effect a tolerable compromise between the imperfect conditions that we have inherited and the ideal conditions that we should like to transmit to our successors.

The anatomists of to-day have an opportunity of providing for the future while cherishing the past; of benefiting posterity without neglecting ancestors; of lightening the burdens of generations to come, while recognizing the value of what was done by the anatomical fathers: of erecting a terminologic monument in which the best of what has been is cemented by their own labors.

Part IX, Bibliography.

In addition to papers directly referred to in the text there are included some in which are used the simplified terms of description or designation recommended by the present writer. A single asterisk indicates a partial, two a thorough, adoption of the system. Had other than neurologic papers been included there would appear in the second category papers by J. H. Comstock, S. H. Gage, G. S. Hopkins and many others.

The names of certain periodicals are abbreviated as follows:

A. A. A., Proceedings of the Association of American Anatomists.

A. A. A. S., Proceedings of the American Association for the Advancement of Science.

A. N., Transactions of the American Neurological Association.

A. P. S., Proceedings of the American Philosophical Society of Philadelphia.

Handbook, Reference Handbook of the Medical Sciences, A. H. Buck, editor, 9 volumes, 1884–1893.

J. C. N., Journal of Comparative Neurology.

J. M., Journal of Morphology.

J. N. M. D., Journal of Nervous and Mental Disease.

AYERS, HOWARD, '93.—Anatomical nomenclature. Letter to the editor. *Science*, XXI, 190-191, April 7, 1893.

BAKER, FRANK, '84.—The rational method of teaching anatomy. *New York Medical Record*, April 19, 1884, 421-425. Six figures.

BARKER, L.F., '96.—Concerning neurological nomenclature. *Johns Hopkins University Bulletin*, VII, 200-201, Nov.-Dec., 1896.

———'95.—The nomenclature of nerve cells. *A. A. A.*, 1895, 40-44.

BARCLAY, JOHN, '03.—A new anatomical nomenclature. O., pp. 182. Edinburg, 1803.

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———'94, *a.*—Exhibition of a suicide's brain with two pistol-ball wounds; remarks on its fissural anomalies. *J. N. M. D.*, Dec. 1894, pp. 4. Also in *A. N. A.*, 1894, 102-105, and *N. Y. State Med. Soc. Trans.*, 1874, 190 194.

———'94, *c.*—Problems connected with the cerebral fissures. *A. A. A.*, 1894, 32-35.

———'95, *a.*—The progress of paronymy. Letter to the editor. *Science*, May 10, 1895, 515-516.

———95, *b.*—The paroccipital fissure, should it be recognized, and under that name? *A. A. A.*, 1895, pp. 69-70, 2 figs.

———'95, *c.*—The cerebral fissures of two philosophers. *A. A. A.*, 1895, 71-73, 1 fig.

———'95, *d.*—The frog was not brainless, but decerebrized. Letter to the editor. *Science*, June 7, 1895, 632.

———'95, *e.*—*Neuron, neuraxis*, etc. Discussion of paper of F. Baker, '95, *a.* *A. A. A.*, 1895, 44-45.

———'95, *f.*—Dissection of the sheep's brain: being part IV of "Physiology Practicums," with plates XVIII-XXV and an appendix on the removal and preservation of the brain. 1895.

———'96, *a.*—"Pontine" or "pontile"? Letter to the editor. *Medical Record*, (N. Y.) XLIX, 823, June 6, 1896.

———'96, *b.*—The names *epiphysis*, *conarium* and *corpus pineale*: correction of an error. Letter to the editor. *Science*, N. S., N., 1896.

———'96, *c.*—A matter of terms. Letter to the editor. N. Y. *Medical Journal*, April 11, 1896, 489.

———'96, *d.*—The dorsal sack, the aulix, and the diencephalic flexure. *A. N.*, 1896. *J. N. M. D.*, Aug, 1896, p. 543. *J. C. N.*, VI, June, 1896, 128.

———'96, *e.*—The ectal relations of the right and left parietal and paroccipital fissures. A. N., 1896. *J. N. M. D.*, Aug., 1896, 543. *J. C. N.*, VI, June, 1896, 129. Abstr. in *N. Y. Medical Record*, July 11, 1896, 61.

———'96, *f.*—Some neural and descriptive terms. Circular letter. *Science*, Dec. 25, 1896, 947. Also in *N. Y. Medical Journal*, Jan. 2, 1897; *Anatomischer Anzeiger*, 1897.

———'96 *g.*—The desirability and the feasibility of the acquisition of some real and accurate knowledge of the brain by precollegiate scholars. Amer. Soc. Naturalists, 1896. *Science*, 1897.

Additions and Corrections.

There are more items under this head than there might have been had it always been practicable to let me see a revised proof. Ordinary errors of typography and punctuation are not specified.

§2 line 4: *For* VII, *read* VI.

P. 217, line 4: *For* VI, *read* VII.

P. 230, note 1: After '84, insert '86.

P. 230, note 2, last line, fifth word: *For* many, *read* neural.

P. 253, last line: *For* collosum, *read* callosum.

§147, line 7: *For* Anzeizer, *read* Anzeiger.

The next three items are trivial in themselves but necessary for the maintenance of the accuracy of reproduction of the original as announced on p. 268, note 3.

P. 269, fifth line from bottom: Coelia has a capital initial.

P. 269, note 1: Between Medical and News is a period. The words between 1890 and 1889 are italicized. The y of February should be omitted.

P. 273: The section now numbered 177 should constitute part of 176; *For* §178, *read* §177.

P. 275, seventh line from bottom: *For* poslcaval, *read* postcaval.

P. 279, seventh line: *For* diffussion, *read* diffusion.

P. 293, Table V, 30: *For* '89, 153, *read* '93, 196.

§235: For certain accidental omissions from the German list, see §241, note.

Pp. 304-307, head-lines: *For* '82, *read* '81.

P. 306, II, B: *For* Corum, *read* Eorum.

§239, *e*, line 7: *For* trapezoides, *read* trapezoideum.

P. 322, II, B, 4, Paracoelia: Of course the equivalency of this word for ventriculus lateralis involves the acceptance of the adjectival force of the preposition, *para*; §§180-190.

P. 326, Table VII, column 8, segment VI, *trapezium:* That this part is here included in the last segment, while in Tabie VI, V, B, 20, it is left in the fifth, as by the German committee, exemplifies the difficulty of assigning parts to these two segments.

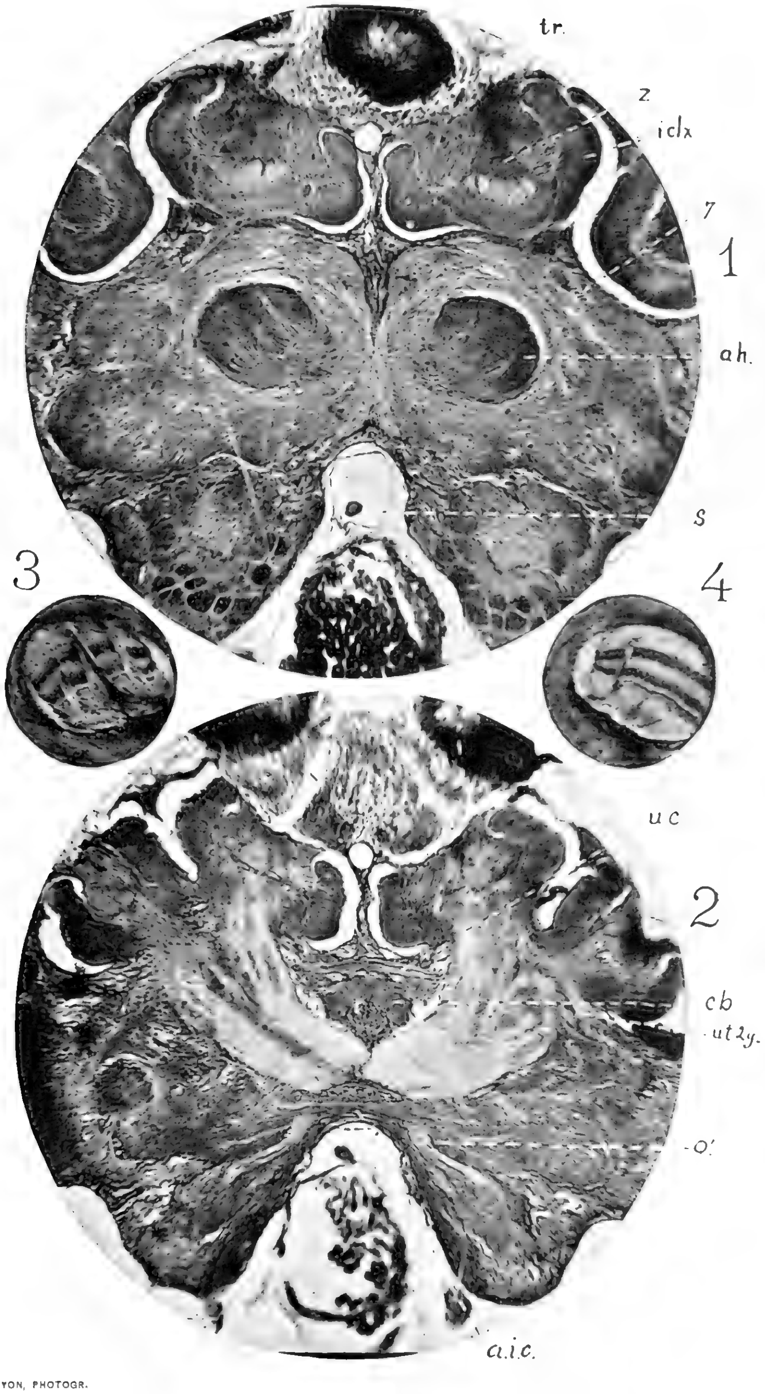
§254, last line: The section here referred to is on p. 274, not the one wrongly numbered §178 on p. 273.

§268, line 1: Omit the periods between B N A.

§268, line 5: After His, read (§2; '96).

§270, note, line 5: After '96, insert *g*.

P. 340, Title 4: This should be the second under Baker, not Barker.



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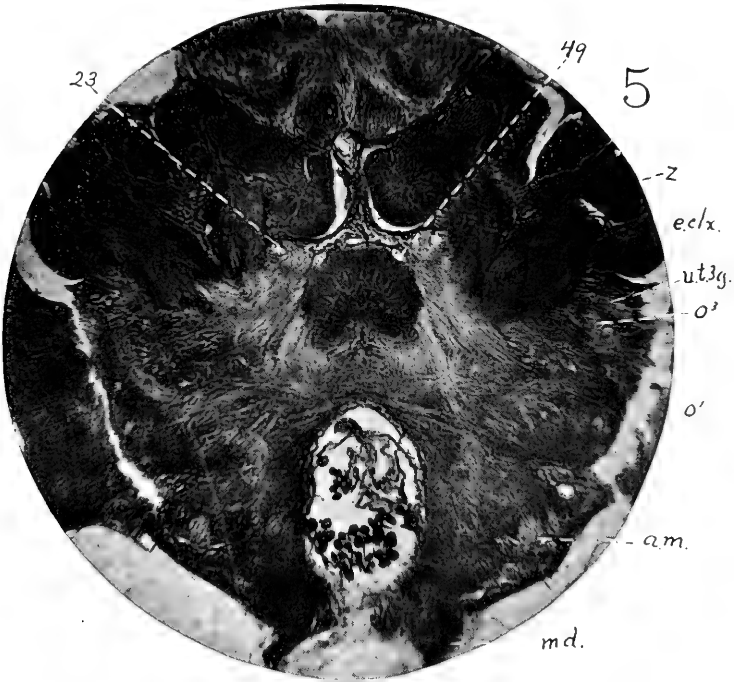

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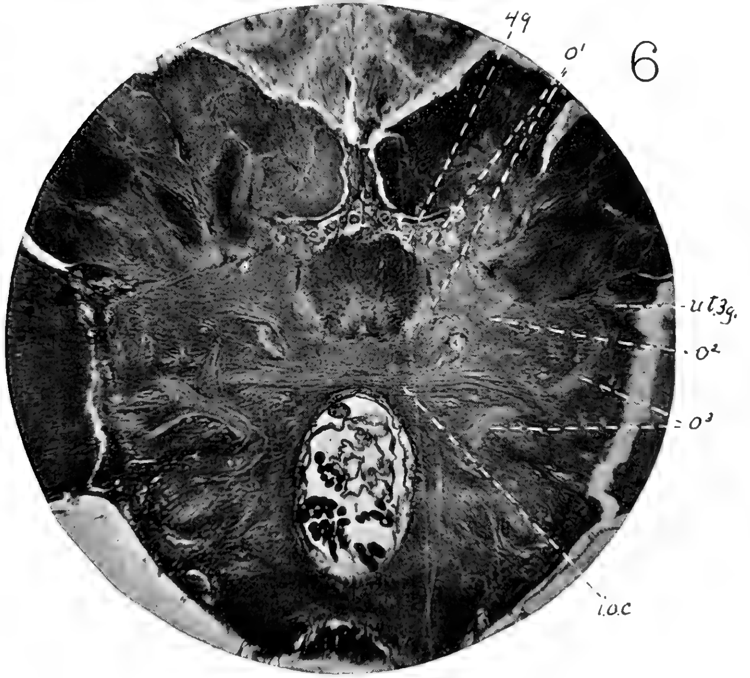
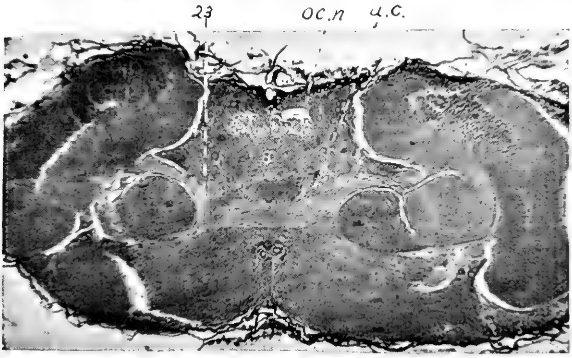


F. C. KENYON, PHOTOGR.



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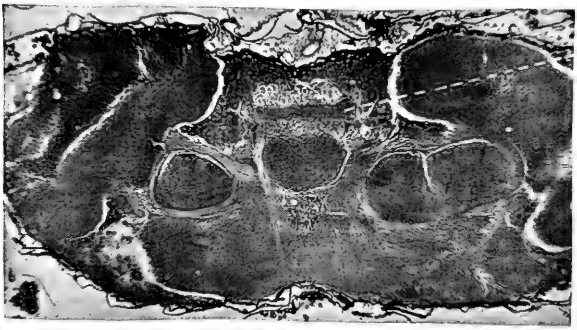

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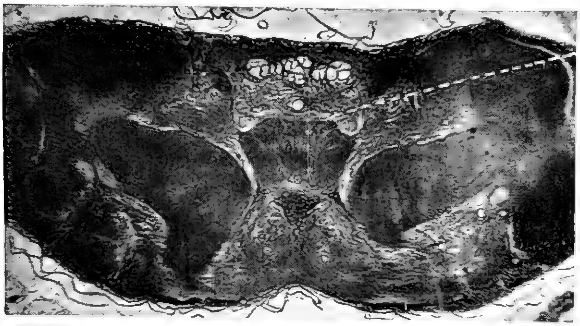

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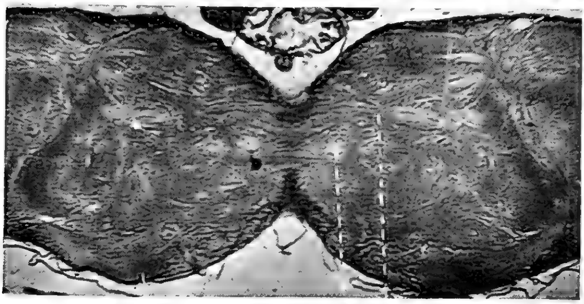

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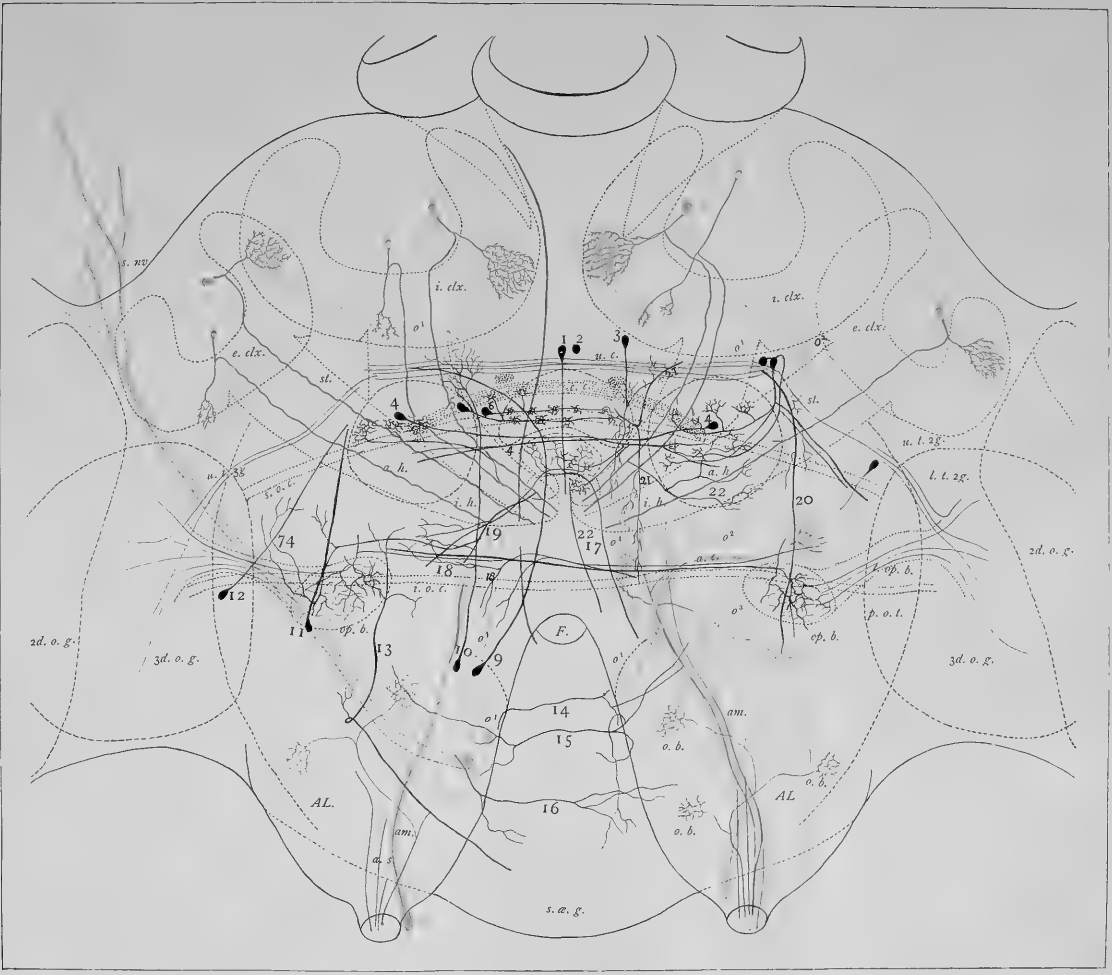

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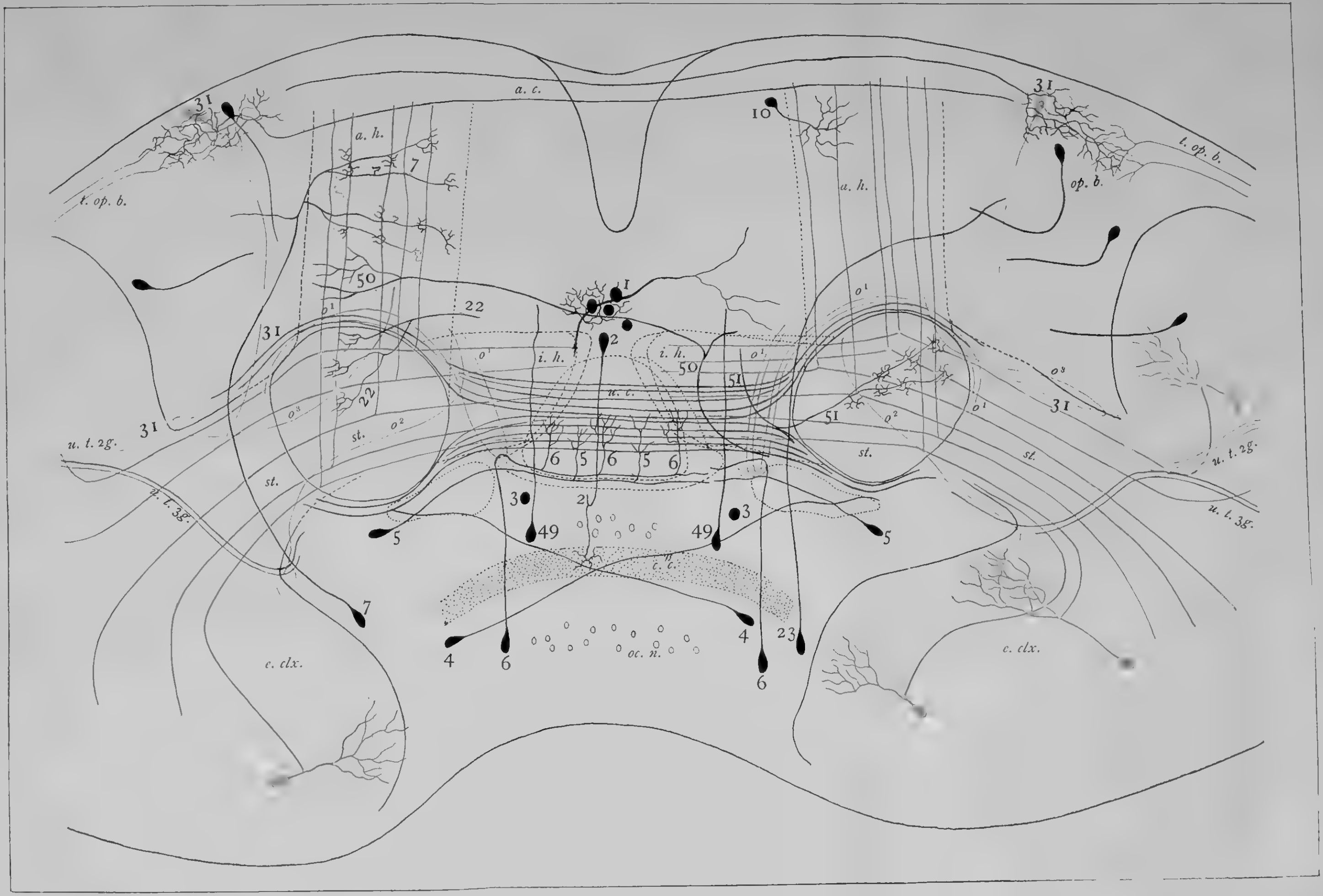

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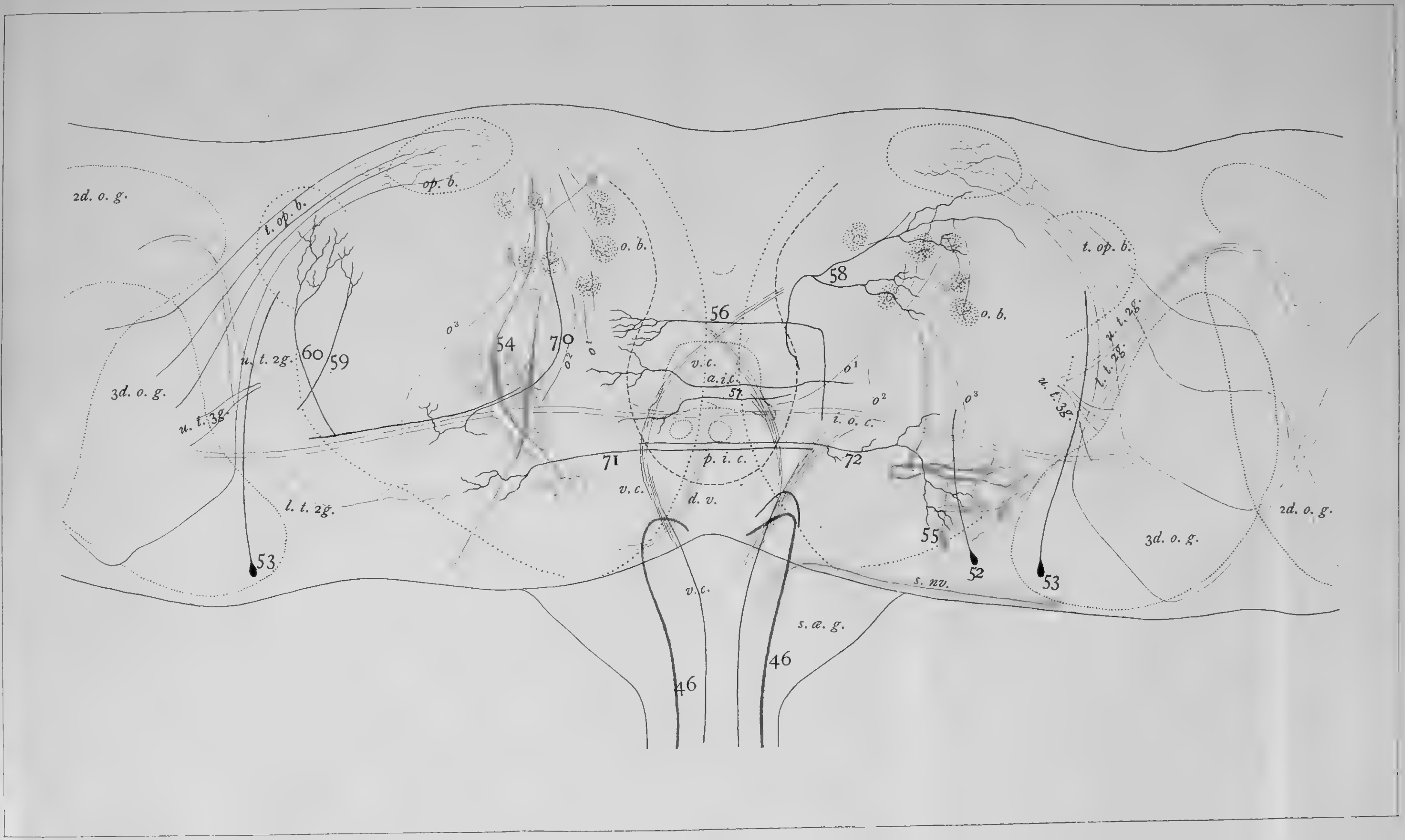

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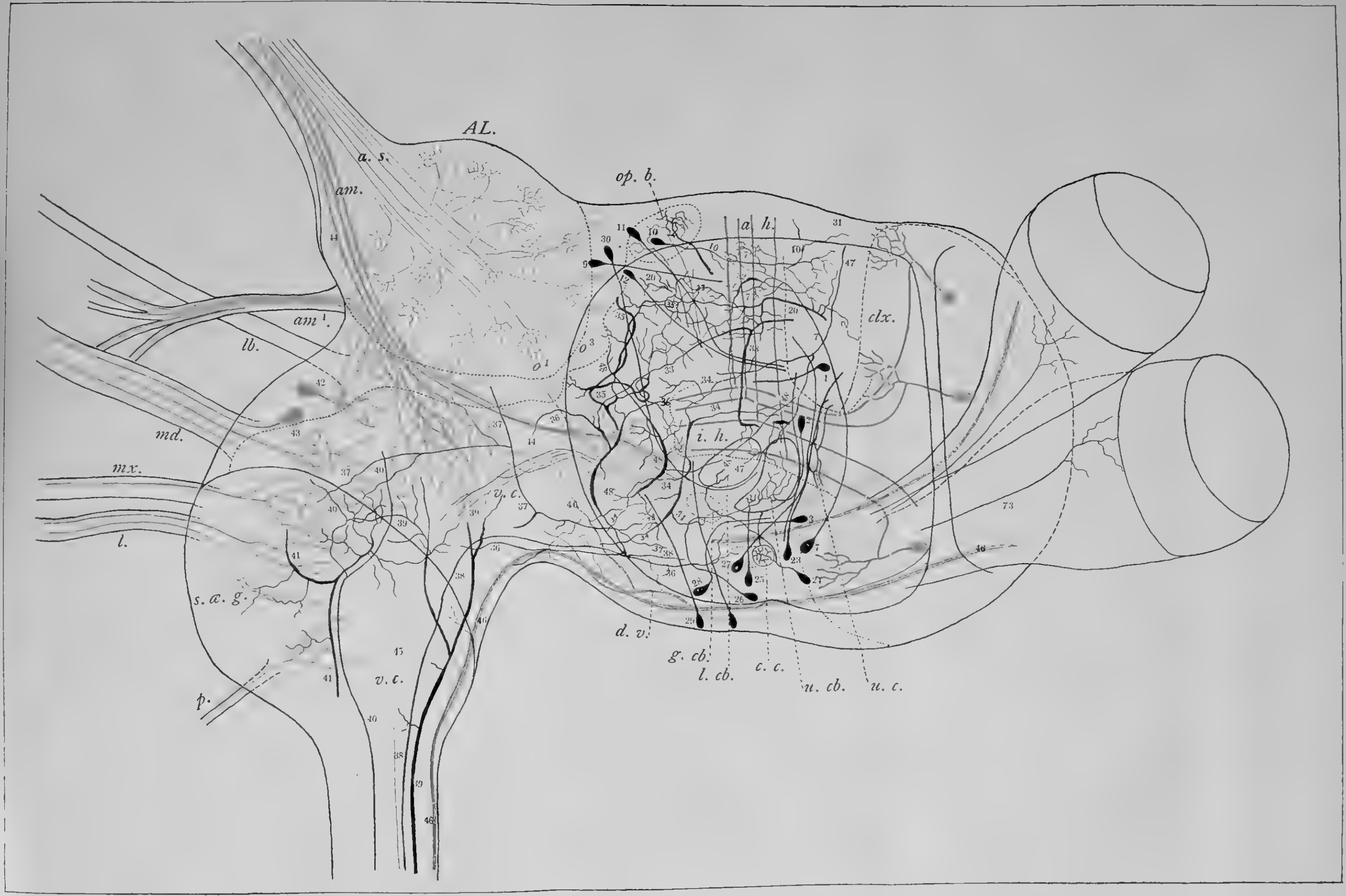

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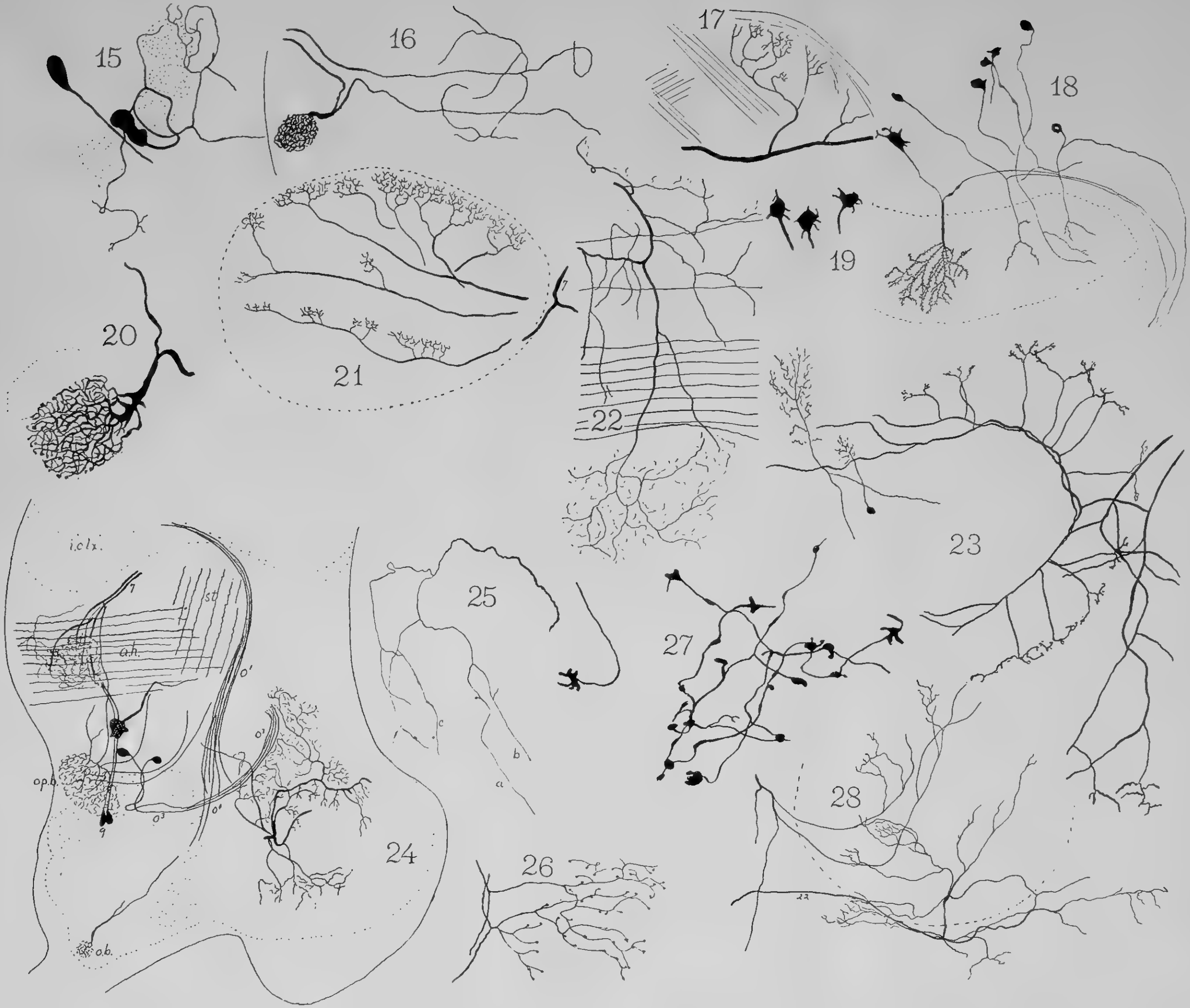

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F. C. KENYON, AD NAT. DEL.

LITERARY NOTICES.

Effects of Alcohol on the Cortical Nerve Cell.[1]

The tendency apparent of late to concentrate the attention upon limited problems of neuro-physiology and attempt their solution by the various improved methods now at our command is bearing fruit in investigations promising to give us definite and reliable data for pathology and psychology. Naturally none of these problems has greater practical and theoretical importance than that respecting the causes and character of cortical degeneration.

Dr. Berkley has sought to contribute to the solution of this problem by minute studies of the changes in the cortical cell produced by the long-continued administration of alcohol to rabbits. 5 to 8 cc. of absolute alcohol were fed to the animals and the dose continued until their death perhaps a year after the beginning of the experiment. The specimens were hardened in alcohol or Müller's fluid. Nissl's method and hæmatoxylin-eosin staining for cellular structures and blood-vessels followed alcohol hardening and an original process, the Müller's fluid. (The reviewer can but express surprise that methods known to induce such shrinking and alteration in the cell bodies should have been employed for hardening). The process referred to is as follows:

"The cerebra are treated with Müller's fluid until the tissue is of sufficient consistency to admit of fairly thin sections. The portions of the brain selected are then cut into pieces not more than three millimeters in thickness, and the slices are immersed in a mixture of 3 per cent. solution of bichromate of potassium, and 1 per cent. solution of osmic acid, in the proportion of 100 parts of the former to 20 parts of the latter. In this mixture the slices lie from three to five days, are then removed from the fluid, and slightly dried on filter paper to remove any superfluous bichromate, are washed for a few minutes in a weak solution of silver nitrate, and then go into the second or staining mixture, which is made by adding two drops of a ten per cent. solu-

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[1] **Berkley, H. J. Studies on the Lesions produced by the Action of Certain Poisons on the Cortical Nerve Cell.—1. Alcohol. *Brain*, IV, 1895.**

tion of phosphomolybdic acid to each 60 cc. of one per cent. argentic nitrate solution in distilled water. The second solution is made only as needed and at the moment before placing the brain tissue in it."

This method is said to avoid the perplexing fringe of brown about the impregnated cells and is rather a stain than a precipitation. It is said to be more reliable also.

Unaltered cells fall into several groups: *arkyochromic cells*, with a reticular arrangement of the chromophilic particles; *stichochromic cells*, with the particles in rows; *cytochromic cells*, with large nucleus and small cell body; *somatochromic cells*, with much protoplasm and small nucleus. The cortical cells are chiefly somatochromic of the stichochromic variety.

In the normal brain the contour of the vessels is regular and the perivascular spaces are narrow but distinct. The nuclei of the walls are sharply stained. In the alcoholic brains the small capillaries are shrunken and irregular. The nuclei are swollen and absorb more stain. The perivascular spaces are enlarged and are either empty or partly filled with hæmatoidin debris. In the somatochrome cells the nuclei are altered in the disposition, size, and regularity of contour of the nucleolar chromophilic particles.

By the silver method Berkley claims to show that all the pyramidal cells of the cortex and many of the irregular and angular ones have short rectangular or oblique projections or gemmulæ given off from the protoplasmic processes and that these are not as Kölliker supposed abnormal or artifacts. Besides these the nerve cells have upon their branches a small, though variable number of varicosities.

The neuroglia cells have nodosities in their fibres which must be carefully differentiated. Making all possible allowances for artifacts and variability the author feels justified in considering a considerable number of the appearances in the silver preparations of alcoholic brains abnormal. The principal lesions are diminution in size, shrinkage of a vast majority of the cortical cells, disappearance of the gemmulæ, certain swellings of the neurodendrites, and roughening of the stronger processes, and to some extent of the cell body. It is a question whether cells undergoing degeneration are as readily impregnated as the normal. Our own experience would lead to the conclusion that active processes, whether normal or pathological, favor reactions while an inert condition due either to fatigue or disease predispose to rejection of the stain.

Tumefaction of the neurodendrite and a loss of the gemmulæ go hand in hand during degeneration. The method employed seems to be ill adapted to bring out the lesions of the cell body, though such an instance as that shown in Fig. 11 proves that the changes are similar to those ordinarily seen in alcoholic dementia where the cell body is excavated or irregularly vacuolated. It is a pity that comparison was not made with cells stained with hæmatoxylin-sublimate-fuchsin or some histological stain after complete hardening in chrom-acetic or sublimate.

In the cerebellum similar changes were found in Purkinje's cells but of a more marked character. It is certainly placed beyond question by this study that alcohol, in common with other irritants, produces a very definite destructive effect on the nerve cells and in particular upon those of the kinesodic system. C. L. H.

Structure of Nerve Cells after Electrocution.[1]

The fatiguing effect of the prolonged action of weak electric currents on the cells of the nervous system is well known through the researches of Hodge, Mann, and Vejas. Are these structural changes increased by the shorter action of much stronger currents, is the question which Dr. Fish set before himself for solution. The first specimen examined, a portion of the cervical spinal cord of a victim of an electrocution at 1740 volts, exhibited a pronounced vacuolation of the nerve cells not to be accounted for by any known conditions prior to the execution. A second case in all essential respects similar and with absolutely fresh material gave, however, negative results, there being no observable lesions in the nerve cells of the same region of the spinal cord under the same method of preparation. The latter case is regarded by Dr. Fish as the typical one and is verified by the results of experimental electrocutions on the lower animals performed by Dr. Krauss of Buffalo. Dr. Fish is inclined to the hypothesis that death by electrocution is the result of the fixation of the cells of the central nervous system, that is the cells are killed instantly in practically their normal relations. C. J. H.

Cortical Pathology of Permanent Dementia.[2]

Dr. Berkley has advanced a theory of the pathology of dementia which is based on the recent advances in our knowledge of the relation

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[1] FISH, PIERRE A. The Action of Strong Currents of Electricity upon Nerve Cells. *Jour. Nerv. and Mental Disease*, N. S., XXI, 1, Jan., 1896; *Trans. Am. Microscopical Soc.*, XXVII, 1896.

[2] BERKLEY, H. J. A Theory of the Causation of Permanent Dementia. *Medical News*, 9 Nov., 1895.

of nerve cells and fibres in the central nervous system, the details of which Dr. Berkley has himself so successfully investigated. He calls attention to the fact that non-medullated nerve fibres are not known to occur to any great extent in the cerebral cortex and expresses the belief that the uncovered free endings of the lateral buds or gemmules of the "psychic" cells of the cortex are the media of communication from one neuron to another. These gemmule-bearing protoplasmic processes are the first to suffer from the ravages of disease, the cell body degenerating later and the axis cylinder being affected last of all. "In short, therefore," to quote from a recent editorial in the *Journal of the American Medical Association*, "the theory of Berkely as to the pathology of dementia is as follows: The conduction of nerve stimuli to the cell corpus is through the medium of the lateral gemmules of the protoplasmic processes; that these are specially liable to injury from toxic or morbid influences, and are the first portions of the neuron to atrophy and disappear in certain diseases of the brain; that with their atrophy and consequent loss of function we have, first, confusion and incoördination of psychic functioning, and finally with any widespread degeneration of the cortical elements a permanent dementia ensues. His conclusions have been deduced partly from examinations of human brains and partly from experimental investigations on animals. He gives with his paper a reproduction of micro-photographs, showing the normal primordial process of a well educated man taken from an autopsy immediately after death, and of a corresponding process from a subject of terminal dementia, showing the atrophy and absence of the dendritic gemmules." C. J. H.

The Functions of the Frontal Lobes.[1]

The satisfactory discrimination of the functions of the frontal lobes from those of other cortical areas is a matter of great difficulty and the attempts hitherto made have produced only ambiguous and conflicting results. Ferrier has decided that the frontal lobes preside over attention while also presiding over motions of the eyes and head. Munk and Luciani consider this region as a part of the Fühlsphære or sensorium and the motor centre of the dorsal muscles. Wundt and Hitzig from a theoretical standpoint assume that it is the centre of higher psychical functions.

The author of the paper before us reaches similar conclusions and offers interesting experimental evidence which if not entirely convinc-

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[1] BIANCHI, L. *Brain*, IV, 1895.

ing, is at least very suggestive. One must of course be on his guard against attributing to the loss of brain substance phenomena which may be due to the stimulating or depressing effects of operation or resulting encephalo-meningitis.

The details must be sought in the original but, in general, in the case of monkeys after ablation of both frontal lobes, the behavior is altered, the physiognomy is stupid and less mobile, the expression is altered and devoid of flashes of intelligence, curiosity or sociability. There is no evidence of affection or gratefulness. Actions of purposive character are liable to be left incomplete. There is loss of cleanliness and discrimination. The disposition is fitful and cruel.

The author denies the existence of a special centre of inhibition or attention but concludes that the frontal lobes are seats of coördination and blending of outgoing products of the several sensory and motor areas of the cortex. "The frontal lobes would thus sum up into series the products of the sensori-motor regions, as well as the emotive states which accompany all the perceptions, the fusion of which constitutes what has been called the *psychical tone* of the individual. The removal of the frontal lobes does not so much interfere with the perceptions taken singly as it does disaggregate the personality, and incapacitate for serializing and synthesizing groups of representations."

C. L. H.

Cerebral Localization.

To the surgeon whose duty it is to diagnose and treat lesions of the central nervous system the present state of the theory of cerebral localization is perplexing enough. He sees some denying the fact of cerebral localization *in toto* and insisting that the cortex acts as a unit; others who recognize the cortical areas essentially as located in the text-books urge that the division of these areas into sensory and motor is a false division, for all of the areas are really sensory, the motor zones exerting no control over the muscles commonly associated with them, but only receiving sensations of muscular and general sensations from those regions of the body; and yet all of the time our leaders in surgical practice are operating successfully on the basis of the old charts constructed on the theories of Munk and Ferrier. In view of this situation a recent paper by Dr. C. K. Mills[1] offers a few timely suggestions. We quote the latter part of the paper:

"For the practical purposes of the physician and surgeon, no

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[1] MILLS, C. K. Cerebral Localization in the Light of recent Pathologic Researches. *Jour. Am. Med. Assoc.*, XXVI, 1, 4 Jan., 1896.

matter what view may be taken of the nature of the processes going on in the cortex, it would seem best to still hold to the view of the separate localization of areas for the special senses, for motion, and even for muscular and cutaneous sensibility. Lesions of these areas produce phenomena of vision, audition, motion, sensation, etc., which are not produced when the lesions are situated outside of the special areas to which the functions above mentioned are assigned. The fillet radiations for cutaneous and muscular excitations, as a compact bundle, probably reach, or most closely approach, the outer layer of the cortex in the postero-parietal convolutions and in the limbic lobe. Whether we should regard the cells and fibers which bring about communication between these regions and the motor cortex as true sensory terminals or as simply constituting a field of conjunction, the only cortical and subcortical lesions which will produce pure and marked sensory symptoms will be those occurring in these areas. 'These incoming messages,' says Andriezen, 'which inform the brain of the movement of the limb, arrive (strictly speaking) not in the pre-Rolandic but in the post-Rolandic (ascending parietal) convolutions. In the pre-Rolandic or ascending frontal convolution, and in the adjoining posterior portions of the three frontal convolutions as well as the prolongation of these areas on the mesial (marginal) convolution, we find the last term in the cortical series, the finally disposed executive mechanisms.'

"It would perhaps be best to define the cortical area for cutaneous and muscular sensations, as that part of the cerebrum where the fillet radiations most nearly approach the surface of the brain, before their final ramifications in the molecular layer, still holding to the old view with reference to the motor cortex. Andriezen, as already stated, speaks of the pyramidal and ambiguous cells as the first sensory cells of the cortex, because the terminals of the fillet radiations, or their extensions, first touch the apical processes of these cells, and therefore these cells first receive sensory impressions from the periphery of the body. It would be better, following Forel and Nansen, to disregard entirely the subdivision into cells of sensation and motion, and take the broad ground that we are simply dealing with the greatest and highest of sensori-motor areas, and that in the region posterior to the area usually recognized as motor, the last stage in the sensory process is reached, while in the Rolandic cortex the first stage in the motor portion of the process begins."

C. J. H.

Motor Functions of Dorsal Spinal Nerves.[1]

The question proposed in this investigation is, "Do the dorsal spinal nerve roots carry functional motor fibres for the splanchnic musculature, on the one hand, and on the other hand, for the musculature of the bladder, which is also derived from the lateral plates?" The investigations of van Wyhe and Hatschek have shown that this is true for selachians, Amphioxus and Ammocœtes; does it also hold for the higher vertebrates?

The dorsal roots of the spinal nerves of the frog were electrically excited with a Du Bois Reymond's apparatus and the results controlled by means of mechanical stimuli of these roots. Such stimulation evoked peristaltic and and anti-peristaltic motions of the digestive tract, and it was demonstrated that the successive pairs of roots correspond to distinct, though not sharply defined successive regions of the digestive tract. This result stands in pleasant harmony with the recent work of Sherrington and others on the segmental distribution of the cutaneous nerves. The innervation is bilateral and the reaction persists after the cessation of the stimulus. The time intervening between the beginning of the stimulus and the first noticeable reaction varies; it is never less than three seconds. These reactions are independent of the vagus or vagus centres. Study of the ventral roots showed that no motor fibres go to the digestive tract from the spinal cord through any of the ventral roots except fibres to the rectum from the sixth and seventh. For the details of the connections of the several roots and of the very interesting relations of the nerves of the rectum and bladder the original must be consulted. The reader will notice that these results stand in harmony with the anatomical discoveries of Lenhossèk and others who have described centrifugal fibres in the dorsal roots.

C. J. H.

Spiral Fibres in the Invertebrates.[2]

Ganglion cells are described in the ventral nerve chain of *Hirudo medicinalis* which are essentially similar to those known in the sympathic system of amphibians and reptiles. The spiral fibre breaks up into a reticulum upon the body of the ganglion cell and the author describes this reticulum as consisting of two parts, one extra-cellular, the

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[1] Steinach, E. and Wiener, H. Motorische Functionen hinterer Spinalnervenwurzeln. *Arch. f. d. ges. Physiologie*, LX, p. 539.

[2] Simon, C. Sur l'existence de la cellule à fibre spirale chez les invertébrés. *Bibliographie Anat.*, III, 6, Dec., 1895.

other intra-cellular. The former is regarded as a reticulum of origin, not of termination, the individual fibres apparently arising within the cell and uniting to form the spiral fibres, which is considered to be a cellifugal prolongation of the subjacent ganglion cell. On the other hand the intra-cellular reticulum is composed of filaments of the same optical properties as those which go to make up the greater process of the ganglion cell and the author suggests that they are the cellipetal fibres which on entering the cell body spread through it and form an intracellular superficial reticulum which in some way is to come into physiological relations with the extra-cellular cellifugal reticulum. We shall await with interest a more full description and confirmation of the preliminary account of relations which are certainly sufficiently remarkable to justify a little hesitation in giving them an unqualified acceptance without the most rigorous proofs.

C. J. H.

Structure of the Thalamus.[1]

Corpus Luysii, or nidus hypothalamicus of man. This receives fibres from the tractus opticus, which come chiefly from Meynert's commissure. Apparently Gudden's commissure also sends fibres into the nidus hypothalamicus. The latter receives other fibres from the lenticular nidus which penetrate it from the lateral aspect and also from the tegmental bundle of the caudatum. Finally there is to be mentioned a commissure of the nidi hypothalamici on the dorsal side of the most caudal portion of the mammillaria.

Opticus termini. In the mouse, termini of the opticus fibres were found in the corpus geniculatum laterale, in the thalamus itself and in the corpus quadrigeminum anterius. In the two first mentioned the termini are like those described for the lobi optici of birds, that is, with much branched, compact terminal tufts which lie partly in the interior of the corpora geniculata lateralia and of the thalamus and partly in the stratum zonale of the latter. In the corpus quadrigeminum anterius, on the other hand, no such tufts were found but endings loosely branched over a larger area, which spread from the second white layer especially into the outer grey zone. In young rabbits were found in the layer of the tractus opticus laterally of the thalamus large cells which send their nervous processes centrifugally into the tractus. It was impossible to determine whether these fibres pass to Gudden's com-

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[1] KOELLIKER, A. v. Zum feineren Baue des Zwischenhirns und der Regio hypothalmica. *Verh. Anat. Ges.*, IX Vers., 1895.

missure or whether they represent the centrifugal fibres found by Cajal in the retina.

Coronal fibres of the thalamus. Investigation of young mammals shows that these fibres in the main present terminal arborizations in the thalamus. The optic radiations, however, undoubtedly terminate in the cortex, as their cells of origin lie among the ends of the opticus fibres.

Fasciculus thalamo-mammillaris, s. Vicq d'Azyr. In new born and young mice it was clearly shown that the fibres of this bundle exhibit terminal arborizations in the nidus dorsalis thalami. This bundle, which according to the researches of Gudden has nothing to do with the pillars of the fornix, must therefore take its origin in the cells of the corpus mammillare—according to Gudden in the caudo-ventral nidus.

Pedunculus corporis mammillaris of the rabbit. The fibres of this bundle undoubtedly arise in the large-celled lateral nidus of the corpus mammillare. Of their termini nothing has hitherto been known. The author finds, however, that they end cephalad of the pons in the region of the caudal end of the ganglion interpedunculare near which they lie, surrounding dorsally and in part also penetrating a round nidus already described by Gudden as lying behind the trochlearis nidus in the central grey, the ganglion dorsale tegmenti of Kölliker. Another part of these fibres ends in the central grey which surrounds this nidus. From this nidus and from the central grey around it there arises the dorsal longitudinal bundle of Schütz which Kölliker has called the dorsal grey longitudinal bundle, and this may be easily followed in longitudinal sections along the dorsal side of the fourth and third nidi and in a curved course along the floor of the third ventricle.

Columnae fornicis of the rabbit. These tracts plainly pass only through the lateral part of the corpus mammillare and end crossed behind and on the dorsal side of the latter. The author has followed these fibres to the nidus of the oculo-motorius, the posterior commissure and the nidus ruber, though these relations are not definately established and the real termini he is not at present prepared to state.

Ganglion habenulae of mammals. The fasciculus of Meynert arises in the ganglion habenulae of the opposite side in free non-medullated arborizations. The fasciculus of Meynert contains fine and coarse fibres, of which the latter possibly pass above the ganglion into the pons. In the ganglion interpedunculare arise the medullated fibres discovered by Ganser which pass in two bundles ventro-dorsally and end in the ganglion tegmenti dorsale and in the adjacent central grey.

Stria medullaris of the rabbit. This ends for the most part in the ganglion habenulae and derives its fibres, (1) from the fornix and the Ammonshorn; (2) from the basal part of the third ventricle, from the regio supra-optica, where the fibres in question arise in a large ganglion which is connected with the nidus of the basal bundle of Ganser; (3) from the stratum zonale of the thalamus; (4) from the interior of the thalamus. The stria thins out from before backward and behind passes over into the commissure of the pineal, from which a small number of fibres enters into the pineal. This commissure is a union of the habenulae.

Fasciculus longitudinalis dorsalis of Kölliker. The so-called dorso-median fasciculus ends in the mammals cephalad of the nidus III in ascending fibres which in part form a commissure, in part apply themselves to the medullary zone on the medial side of the nidus ruber. A nidus of this bundle such as was found by Van Gehuchten in fishes cannot be demonstrated in the mammals.

C. J. H.

The Lateral Line System of Amphibia.[1]

Dr. Kingsbury has performed a service which will be appreciated by many students in several departments of research in mapping the exact distribution of the lateral line organs of many of our types of tailed Amphibia, as well as of some of the allied forms. Descriptions and figures of the following species are given, *Necturus maculatus*, *Amblystoma punctatum*, *Protopterus annectens*, *Amphiuma means*, *Gyrinophilus porphyriticus*, *Diemyctylus viridescens*, *Siren*, *Rana*, *Cryptobranchus allegeheniensis*, *Lepidosiren paradoxa*, as well as comparisons with several other types. The histology of the neuromasts (Nervenhügel) is briefly discussed. We quote a few paragraphs.

"The Amphibia afford in certain respects peculiar opportunities for the study of a sensory system associated with existence in the water. This is due to the fact that there are here included forms purely aquatic and forms as purely terrestrial in their habits of life, and yet others which spend a portion of their life in the water and a portion of it on land. In every family of the tailed Amphibia native in the United States the system has been found, and in five families of the tailless Amphibia. Since Malbranc has found the sense organs in a larval *Pipa*, and Leydig in a larva of the viviparous *Salamandra atra* taken from the oviduct of the mother, doubtless the system will be found in

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[1] KINGSBURY, B. F. The Lateral Line System of Sense Organs in some Amphibia, and Comparison with the Dipnoans. *Trans. Am. Microscopical Society*, XVII, 1896.

a more or less perfect state of development in all Amphibia at some period in their life-history.

"In the urodela the distribution may readily be reduced to the following type: Upon the body, three lines, a *lateral* continuous or not continuous with an occipital group, though not continuous with the orbital lines; a *ventral* line extending from under the arms in the pectoral region to near the hind legs; a *dorsal* line somewhat closely connected with the lateral at its cephalic end and seldom extending as far as the level of the vent. Upon the head, a series extending from behind the eye, above and below it to the snout, the *supra-* and *infra-orbital* lines; a line upon the lower lip, the *oral*, connected with the infra-orbital by the *angular;* a line from the angle of the mouth to the lateral corner of the head and there meeting a diverging line upon the ventral side of the head, and, when this is sufficiently developed, a line or trend of organs upon the side of the head; these the *jugular, gular* and *postorbital* lines of the descriptions and figures.

"Comparison with other Ichthyopsida may not be of much value; however, the distribution approaches most nearly that in the Dipnoans, then in Elasmobranchs; among the latter *Chlamydoselachus*, apparently, in the greater extent of the gular line, shows most resemblance to the Amphibia.

"The significance of the arrangement into groups is apparent when the system is examined in the larva at different periods of development. Evidently, as has already been maintained by Malbranc, each group sprang from a single organ by repeated fission in the same plane. His figures and my own observations clearly show that such is the case, as illustrated by Fig. 45. Exactly how this takes place, however, is unknown. Whether the sensory cells may arise from the supporting cells, or from sensory cells alone, and supported from supporting cells or from ordinary epidermal cells, yet awaits solution.

"Malbranc called attention to the often recurring arrangement of groups upon two coördinates perpendicular to each other, or nearly so (as in the gular line), pointing out the physical advantage in such an arrangement in perceiving the direction and strength of a vibration in the water, should such be their function. In Ichthyopsida, in which the sense organs are deeply sunken in canals, the pores often become many times divided. In *Amia*, Allis found that the primitive pores divide quite regularly in a certain plane for a number of times; these secondary pores again often divide in a plane at an angle to the first, generally a right angle or nearly so, reminding us of the groups in Amphibia. In forms, then, in which the sense organs are confined in canals, this division of the pores would seem to represent a potential division of the sense organs, which in forms in which the sense organs are freely situated, as in Amphibia, can be actual.

" Attention is called to the necessity, imposed by the life habits of certain urodeles, *e. g.*, *Diemyctylus*, for the neuromasts to live over a period of terrestrial existence, which is accomplished by the protection of the organs by a growth of epidermal cells. Doubtless this is also true for many other forms of semi-aquatic habits of life, *e. g.*, *Desmognathus*. In certain other urodela, *e. g.*, *Salamandra*, and I bebelieve *Plethodon* (if they exist at any time), the system perishes entirely in the adult. This is also the case apparently in all the Anura, though in *Rana* it persists until after both legs and arms are well developed and the tail has begun to be absorbed. There would seem, then, to be something other than an aquatic existence necessary for the maintainance of the neuromasts, since *Rana catesbiana* is more purely aquatic than several of the Salamanders in which the system persists. Of the mode of final disappearance nothing is known."

C. J. H.

Brains of Sauropsida.[1]

The large number of carefully prepared descriptive papers now issuing from the Cornell University laboratory of neurological research is an occasion of congratulation not only to the directors of this laboratory but to morphologists in general. It is everywhere recognized that the greatest obstacle now in the way of the best morphological work is the lack of sufficiently full knowledge of the exact anatomical structure of the types under investigation.

Studies like the one now under consideration with their detailed descriptions and full illustration should do much to check the prevalent tendency to morphological speculation by supplying such a basis of exact knowledge as will render possible the more satisfactory determination of morphological fact.

Mrs. Gage has chosen for study the soft-shelled turtle and the sparrow, not because they represent generalized types of Sauropsida, but on the contrary because they represent extremes of specialization of the two great divisions of this group. This is based on an appreciation of the importance of comparing through all stages of development

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[1] GAGE, SUSANNA PHELPS. Comparative Morphology of the Brain of the Soft-Shelled Turtle (Amyda mutica) and the English Sparrow (Passer domestica). *Trans. Am. Microscopical Soc.*, XVII. 1896.

widely different forms of brains in order to gain from exaggerated form and specialized function more light upon the truths of morphology and evolution, a principle which might profitably be employed more often than has been customary.

The nature of the paper is such as hardly to admit of adequate summary. C. J. H.

Trophic Nerves.[1]

1. The functional influence of a nerve cell on an adjacent cell is always of a trophic nature, either catabolic or destructive, with augmentation of tonus [contraction], or anabolic, restorative with diminution of tonus [relaxation].

2. The section of a nerve, however carefully executed, always provokes in that nerve an irritative process which is feeble, it is true, but of long duration.

3. This irritation of degenerescence, due to the section, evokes variable consequences varying with the functional nature of the nerve. If the nerve conducts catabolic impulses, it produces in the cell with which it is in contact destructive phenomena, long continued and permanent; the cell atrophies.

4. If on the contrary the cell transmits anabolic impulses [inhibitory nerves, dilators], it produces in the cell with which it is in contact feeble but repeated and permanent plastic processes, which cause cellular hyperplasia with karyomitosis. In this case too there is little increase of function.

5. If the nerve sectioned contains both anabolic and catabolic fibres, we find both processes side by side.

6. The existence of trophic nerves in the sense just indicated can no longer be reasonably denied.

—*Revue Neurologique.*

Ampullo-oculo-motor Connections.[2]

The anatomical relations between the vestibular and the oculomotor nerves so far as known are indicated in the accompanying diagram which we copy from Dr. Bonnier's paper. The diagram shows the direct connections between Deiter's nidus and the internal nidus on the one hand and the abducens nidus on the other hand; also the indirect connection between the former and the latter through the superior

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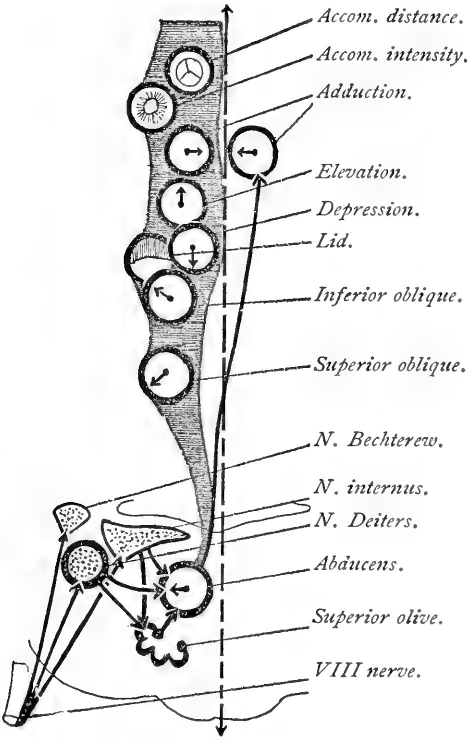
[1] WINKLER. Les nerfs trophiques. *Flandre medicale*, 2 May, 1895.

[2] BONNIER, PIERRE. Rapports entre l'appareil ampullaire de l'oreille interne et les centres oculo-moteurs. *Rev. Neurol.*, III, 23, 15 Dec., 1895.

olive. It shows further the tract of Duval and Laborde which puts into direct connection the abducens of one side and the nidus of origin of the fibres of adduction [oculo-motor fibres] of the opposite side, thus providing the mechanism of the conjugate movements of the eyeballs in the horizontal plane, and also the connection via the dorsal longitudinal fasciculus between the sixth nidus and the fourth and third.



Now the author seeks to correlate these anatomical facts with the results of some experimental work and a large series of clinical observations. De Cyon first called attention to the oculo-motor disturbances associated with lesions of the labyrinth, a fact with which all experimenters on the labyrinth have been forcibly impressed. The most frequent phenomenon is nystagmus, though all disturbances may be met for they are all observed in the clinic.

De Cyon was of the opinion that the directions of the oscillations of the eyeball were determined by the choice of the canal excited.

Breuer called attention to the inertia of the eyeball by which on a sudden movement of the head the eyeball would be displaced in its orbit, thus interfering with the precision of the visual judgment of the actual angular displacement of the head. The nervous connections with the ampullae are for the purpose of correcting this displacement of the eyeball by the contraction of the appropriate muscles, the latter being reflexly excited by the head movement as registered in the vestibular sense organs. It is movements in the horizontal plane which are chiefly to be compensated and it is a significant fact that it is the abductors and the adductors of the eyeball which are in most intimate connection with the vestibular apparatus.

The view of Mendel that vertigo is an oculo-motor disturbance is combated; on the other hand it is regarded as in every case due to an irritation of the connections of the eighth nerve. No doubt titubation can produce vertigo, but the reverse is the rule, and the fact that we see objects oscillating is a sort of reflex titubation of the eyeballs secondarily induced by reason of the intimate relations existing between the muscles of the eyeballs and the vestibular connections.

Upon the irritation of the labyrinth the abductor of the same side and the adductor of the opposite side are excited and the eye quickly turns toward the side of the irritation; the elasticity of the opposing muscles returns the eye to its normal position, but more slowly so that the only disturbance of sensation which results is an apparent rotation of the visual field in the direction opposite to the latter motion. In other words objects appear to move toward the side of the irritation. This is a fact which the author has found to be of the greatest value in clinical practice. Vertical nystagmus is very rare. The author has observed two cases of which the origin was purely labyrinthin. The details of several cases of ocular disturbance occasioned by both labyrinthin and bulbar lesions are given and at the close the author concludes: "Ampullar disturbances can find their symptomology in all kinds of oculo-motor disturbances, and in the presence of the latter it should be remembered that after the retina itself it is the labyrinth and particularly the ampullae which are concerned with oculo-motor functions as well as with equilibrium. All of the oculo-motor nidi, with the exception perhaps of that of the oblique, which I have never seen involved, may thus be affected by reflex irradiation issuing from the ampullar apparatus."

These results of Bonnier agree also remarkably well with those obtained by Lee in his experiments upon the dog fish (*Galeus Canis*).

C. J. H.

The Initial Stages of the Degeneration of Nerve Fibres.[1]

The phenomena attending the degeneration of the nervous tissues have long been matters of the highest interest to the pathologists, and especially since the recent studies on the regeneration of nerve fibres any facts bearing on the histological processes involved in degeneration have an added interest. Numerous pathologists have described the changes observed in the structure of the nerve fibre in the various central and peripheral neuroses and now Dr. Klippel coördinates these morbid processes and finds that they may be resolved into a single process which is essentially the same in all cases.

The first stage in the degeneration of the nerve fibre is apparently a remarkable hypertrophy of the nerve tube. It is not, however, a true hypertrophy, but a tumefaction, the first stage of a lesion essentially destructive. The myelin becomes hyaline and loses in the axial portion next to the axis cylinder the concentric appearance so characteristic of the normal fibre. This portion also becomes granular and stains more intensely than the normal myelin, though not so dark as the axis cylinder. The fact that this disintegration of the myelin begins axially and not peripherally indicates that the morbid process has its origin in the axis cylinder. And in fact simultaneously with the changes just described the axis cylinder also exhibits hypertrophy with a peculiar change of form. In transection it appears no longer as a circular dot in the centre of the sheath but as a greatly enlarged and variously shaped figure, a rod, a spiral, a circle or a sigmoid. In tracing a fibre from section to section this alters in form showing that the contour is flexuous and that the fibre is still in a state of degenerescence. Later, in the penultimate stage of the process, granular fragmentation occurs to be followed by the final complete resorption.

The degenerative process of the nerve fibre may then be divided into three stages, the swelling and deformation of the axis cylinder with the figures just mentioned, the granular disintegration and fragmentation of the axis cylinder together with the liquefaction of the myelin from the centre toward the periphery, and finally complete resorption.

In diseases like general paralysis the cells of the cornua of the cord are affected in a manner strictly analogous. The study of the early stages of this process is of course attended with the difficulty arising from the scarcity of material for histological examination taken at the proper stages of the disease, yet a goodly number of cases are on

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[1] KLIPPEL, M. Comment débutent les dégénérescences spinales. *Arch. de Neurologie*, 2 Serie, I, 1, Jan., 1896.

record, sufficient to show that the process is essentially the same in both the acute and the chronic degenerative neuroses. The chief difference between the acute and the chronic cases is that in the initial stages of the former the tumefaction is more pronounced than in the latter case.

Though the number of these degenerative neuroses is considerable, yet the lesion of the nerve fibres involved is essentially the same for them all. C. J. H.

Cortical Olfactory Apparatus.

Mr. G. Elliot-Smith continues his contributions to the morphology of the smell centre.[1] He notes the simplicity of arrangement of these centres in non-placental mammals and and the similarity, already insisted on by the reviewer, to that in Sauropsida.

The hippocampus (cornu Ammonis, subiculum and fimbria) forms in a typical early mammal the dorsal margin of the whole extent of the fissura choroidea. The ventral margin of the cerebrum in the same region is formed by the pyriform lobe. The prosencephalic part of the olfactory bulb is continued caudad as a short peduncle, which almost immediately divides into the ventro-mesal tuberculum olfactorium and a lateral pyriform lobe. The tuberculum (our post-rhinal lobe) is described as we have described it in the opossum and rodents. "These three parts—hippocampus, pyriform and tuberculum olf.—together with the precommissural area [our intraventricular lobe] and 'septum lucidum' constitute the smell centre." "All the rest of the cortex may be distinguished as 'pallium.'"

If this distinction is adhered to of course in such cases as ***Perameles*** the pallium becomes greatly reduced. This prepares us for Brill's assertion that in Sauropsida the "pallium" disappears. (Probably in no other branch of science than neurology is there such a felicity of whimsicality as that which leads authors to appropriate a word and then supply it with a modified connotation or alter its application and then permits them to use a discrepancy of their own creation to discredit the unfortunate coiner of the word.)

It seems to the writer that if it could be shown that every spot on the superficial aspect of the cerebrum had been encroached upon by cells connected with the smell centres it would not be necessary to reject those areas for that reason from the category of "cortex" or of "pallium."

Do we not tend to undervalue the plasticity of the brain? In the

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[1] *Anat. Anzeiger*, XI, 2.

tuberculum and intraventricular lobe we have an entirely different histological structure from that of the cortex. In relation with the irregularly grouped polyhedral cells of this region fibres from the bulb terminate. Here we have every morphological and physiological reason for assuming an infra-cortical station. All analogy requires it and all the histological appearances are in accord. Processes from these cells ascend to their cortical fields in the hippocampus. The hippocampus is just as much a part of the cortex as the temporal lobe!

"The olfactory peduncle, tuberculum olf. and pyriform lobe are closely connected with the other hemisphere by means of the anterior commissure. The precommissural area (intraventr. lobe) is connected with the other side by a part of the hippocampal commissure, which Herrick calls 'corpus callosum.'"

By means of a very strong fibre system situated in the substance of the tuberc. olfact. and in series with the internal capsule fibres, the olfactory lobe (possibly the bulb?) is intimately connected with the lower parts of the nervous system. In Perameles most of them enter the pes, a few end in the mammillary region.

Mr. Smith, like Debiere, excludes the callosal gyrus from the "limbic lobe." Interesting details respecting the fornix fibres are also given in the same paper.

In the second paper by the same author[1] we note with gratification the tendency toward substantial agreement among different authors respecting homologies which have given so much trouble. In this respect the study of the Ornithorhynchus and lower marsupials has been of great help. The long neglected hippocampal commissure seems to be coming to its own though even Mr. Smith seems not to be aware of what has been more lately done in its study among Sauropsida.

Smith finds that the cephalic part of the dorsal commissure ends in the intraventricular lobe but freely accords to it an independent existence, which is a distinct gain. It is a matter of very subsidiary importance whether this cephalo-dorsal commissure of infra-placentalia is a homologue of the callosum. The best way to show conclusively that it is not would be to find it present in a mammal also possessing the callosum. If its fibres do not pierce the cortical areas at all a strict homology would perhaps be destroyed. Nevertheless it would be an unusual method in nature for fibres to break from one external (median) aspect of one hemisphere and break into a corresponding aspect of the

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[1] Notes upon the Morphology of the Cerebrum and its Commissures in the Vertebrate Series. *Anat. Anz.*, XI, 3.

other. Callosal fibres have developed along some pre-existing route of connection and then attained their present position in obedience to the usual laws of developmental adjustment. Smith says that the fibres "probably belong to the lamina infra-neuroporica and supersede the cephalic part of the fornix commissure whose position they usurp." "The corresponding region of the hippocampus [in higher mammals] disappears and the supracallosal gyrus of Zuckerkandl is all that remains of this region in the Eutherian brain."

If this suggestion as to the origin of the callosal fibres could in any way be verified the last serious obscurity in this problem would seem to be solved.

In a still more recent paper on "Jacobson's Organ and the Olfactory Bulb in Ornithorhynchus"[1] the same author corrects some very serious blunders in Dr. Hill's paper in the *Philos. Trans.* 1893, whose specimen had the bulb artificially disconnected and rotated through 45 degrees. The author finds the same olfactory fossa which we have called attention to in Reptilia and opossum and verifies its relation to Jacobson's organ. In Platypus it is much deeper than even in the black snake but is on the dorso-lateral rather than mesal aspect. A study of the relations of the part of the olfactory bulb associated with Jacobson's organ does not reveal any arrangement different from the rest of the bulb. It would appear that in all its connections with the brain the organ of Jacobson exactly resembles the olfactory apparatus proper and like the latter has its centres in the pyriform lobe and probably also in the hippocampus. C. L. H.

Fibre Connections of the Olfactory Lobe of Man.[2]

It will be recalled that recent investigators have shown by a variety of methods that the connections of the olfactory nerve in the olfactory lobe are practically the same in all vertebrates, the peripheral nerve forming a terminal arborization in the glomerule, there to enter into relations with the protoplasmic process of one or more of the mitral cells of the olfactory lobe whose axis cylinders effect the cortical connections. In batrachians, reptiles and birds each mitral cell gives off more than one protoplasmic process and thus is related to more than one glomerule. No mammal hitherto studied has shown this arrangement, there being but one protoplasmic process to each mitral cell. In

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[1] *Anat. Anz.*, XI, 6.

[2] GEHUCHTEN, A. VAN. Le bulbe olfactif de l'homme. *Bibliog. Anatomique*, III, 4, Aug., 1895.

all lower vertebrates and in some mammals—cat, rat, mouse, rabbit—each glomerule receives the protoplasmic process from a single mitral cell, while in the dog five or six mitral cells effect connections with the same glomerule, thus putting each olfactory fibre into relation with a larger number of cortical cells. Examination of the olfactory lobe of the still-born child with the silver method shows the usual mammalian type with the following exceptions: (1) the mitral cells are more irregularly arranged than in other mammals, lying often in the glomerular layer or even among the peripheral nerve fibres; (2) the protoplasmic processes of the mitral cells occasionally branch, communicating with more than one glomerule as in the lower types; (3) most of the glomerules receive the protoplasmic process of but a single mitral cell, though sometimes two to four mitral cells are related to the same glomerule as in the dog. C. J. H.

The Relation of Sensory and Motor Areas of the Cortex.

The evidence has accumulated in abundance to show that the separation of motor and sensory areas is arbitrary and untrue to the actual facts. The ease with which motor disturbance can be demonstrated may very well account for the pre-eminence given to the location of motor functions. Munk has shown in a series of brilliant experiments that even in the visual area the various portions may produce complex motor responses in the form of coördinated eye movements. The same author has shown that the various cortical motor areas are not exclusively so but that approximately the same regions have a sensory function also. But for our present purpose it is of importance to show that the same generalization holds good for the human brain. From the vast material at our disposal it is only necessary to call attention to the selected cases described by by Dr. C. L. Dana.[1] The analysis of these cases shows, as the author states, that it is the power of localization which is first to be disturbed in case of injury to the cortex, next tactile anæsthesia then analgesia, then simple muscular anæsthesia and, finally, loss of temperature sense. Now the higher forms of coördinated sensations owe their existence as much to vestiges of earlier sense presentations as to the actual sense content. This is especially true of localization and muscular sense. It appears then that one of the most constant of the results of cerebral injury is the impairment of the vestiges or the interruption of the paths connecting with the store-house of such impressions. It is a well-known fact that the extent to which vestigial

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[1] *Journ. Nerv. and Ment. Dis.*, Dec., 1894.

impressions are made or memories are accumulated depends on the intensity of the impression or stimulus as well as on the lack of competitive impressions. This may mean that the amount of irradiation of the stimulus is the factor. At any rate it is easily intelligible that the vestiges will be first disturbed and that they may in time be renewed, explaining the frequent return of the power of localization and coördination where the tactile sense is not wholly destroyed.

The anatomical structure of the cortex is, so far as can now be gathered, conformable to the necessity imposed by the construction of the pathological data. Not only is each cell brought into rapport with many others by the neurodendrites but these connections are in both rank and file. For every cell that gives rise to a kinesodic fibre or neuraxon there are many which form its sphere of influence. It is in accord with the dynamic theory of nervous action to suppose that in the reaction between the numerous æsthesodic cells *inter se* and the other reaction between these cells and the motor initiatory cells is the immediate occasion of consciousness. C. L. H.

Is the Decorticated Dog Conscious?

It is unfortunate that so few of the students of brain anatomy and physiology are also acquainted with the first principles of psychology. The result of this one-sided furnishing is often a deplorable inability to construe the results of experiment and pathology. If this were all, the result would have less significance but upon the false conclusions thus reached a superstructure is often raised, vitiated throughout by the same fundamental fallacy. In no instance has this lack of psychological insight been more evident than in the various attempts to explain the results of total or maximal extirpation of the hemispheres. Every one will, of course, think at once of the celebrated instance of nearly complete removal of the hemispheres by Goltz and the subsequent reports by that author and Dr. Edinger. After eighteen and a half months it would seem that the immediate results of the operation could safely be considered as eliminated and the results, excluding degeneration phenomena, might be taken as those normal to the brain minus the hemispheres. Even so, the purely physiological questions are by no means as simple as might be supposed from current discussions. For one thing, the great inhibitory influence of the cerebral hemispheres being removed, nothing is more certain than that the infracortical centres would not operate in the same way that they normally do in the uninjured brain. Again, the effect of the concentration of stimuli intended for the great terminal projection system upon one of a lower order could hardly fail to greatly alter the reaction. In spite of these sources of error it is not our desire to intimate that, on the whole, the activities of the decorticated dog are not fairly indicative of the functions of the infracortical centres. Strong irritation of the skin caused the animal to growl and bite, he could be awaked from natural sleep by loud noises, the taste of food awakened the impulse to feed, etc. But when an author seriously claims that these facts prove that "we have undoubted manifestations of the presence of every variety of sensation, tactile, muscular sense, sense of pain, vision, hearing, taste, and finally the visceral sensations of hunger and of thirst,"[1] he betrays a lack of psychological discrimination and begs the real question. Here, as so generally, the content of sense is put for sensation and then the conclusion is reached that sensation is produced in the infracortical centres. Now it would be just as legitimate to decide that because certain processes of a nervous character and essential to vision are carried on in the eye therefore the eye is the seat of visual sensation. There is no manner of doubt that all the preliminaries to vision including a large number of coördinating reflexes are all provided for in the infracortical centres. It is equally certain that there is a provision for reflexes of a higher order—such as grow out of the relations of different senses *inter se*. All that is reported in the case of the decorticated dog may well belong in the categories of infraconscious coördination. It must be remembered that the consciousness of a sensation is probably never attained until there has been a kinesodic response to it and it is not unlikely that it is the reflected current rather than the direct one which enters consciousness. It is in this way that the storage of vestiges in the cortex may be explained in such cases where the original stimulus never reached consciousness. It is absolutely necessary that the line between physiology and psychology should coincide with that which separates the conscious from the unconscious or that the distinction be abandoned. If sensation is selected as the unit of psychology it is absurd to speak of unconscious sensation. The fact that the dog in the present instance acts as though conscious of a stimulus is no proof of such consciousness and all admit that there is a complete absence of all evidence of reproduced sensation or of reflection. It is true that very complicated sets of cyclical reflexes are produced but something very similar might under proper conditions be reproduced upon a corpse. The fact that the cortical connections are not completed until a very late period of the ontogeny, which is adduced in support of the idea

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[1] W. H. THOMPSON. *Journ. Nervous and Mental Disease*, June, 1895.

that the dog is really conscious, in reality looks the other way. The presence of consciousness for some time after birth would be a great embarrassment to the economy of the animal. The relation between consciousness and educability is not denied, but it does not follow that the reflexes are not capable of education while the sphere of profitable interference of the conscious is relatively very small.

C. L. H.

The Paraphysis.[1]

This paper is mainly concerned with a summary of other and earlier papers by the same author, with, however, some new observations and an excellent series of photographs. He reiterates the belief that the paraphysis is an evagination from the cerebrum and is only secondarily associated with the diencephalon and that it represents, like the parietal eye, an aborted sense organ. This seems to us an improbable view and one requiring stronger evidence than that presented by the author's photographs. Yet the remarkable constancy with which this structure appears in the embryos of all vertebrates certainly does indicate that the paraphysis has now or has had an important part to play in the evolution of the vertebrate brain. Just what this part may be we cannot by any means regard as satisfactorily determined.

In an earlier work the author described the parietal eye of Anguis as originating by a constriction of the distal end of the pineal evagination essentially as described by Spencer and the majority of other investigators. Béraneck, however, finds that the parietal and pineal evaginations have distinct origins from the roof of the diencephalon, and now Francotte comes over to the same ground, the error in the first case having arisen not from inaccuracy of observation, but from an anomalous condition in the embryo under under investigation. Photographs of the normal and the abnormal brains are given. Five embryos taken from the same mother were found all to present the same anomaly. Whichever view of the origin of the parietal eye may prove to be correct, this paper will do good service in calling attention to a source of error and of disagreement in many another controversy besides this one. It is a significant fact that it was during the same year in which Francotte's paper appeared that Prenant published his paper on accessory parietal eyes in Anguis fragilis, in which he made a sta-

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[1] FRANCOTTE, P. Note sur l'œil pariétal l'épiphyse, la paraphyse et les plexus choroides du troisème ventricule. *Bull. l'Acad. Royale de Belgique*, 3 Series, XXVII, 1894.

tistical study of the variation of these organs and got some surprising results. Cf. Vol. V. of this Journal, p. *xvi.*

C. J. H.

A New Journal.

The first number of the "*Rivista di Patologia nervose e mentale*" appears with the new year issuing from the Clinic of Psychiatry of Florence. The directors are Dr. E. Tanzi, associated with A. Tamburini (Reggio Emilia) and E. Morselli (Genoa); the editors are E. Belmondo and E. Lugaro, together with an able board of colloborators. We are promised in the prospectus monthly issues making in the aggregate about 500 pages per year. The field to be cultivated is that of an "Italian *Centralblatt*," and, judging from the two numbers which have thus far reached us, the labors of the editors are being wisely and fruitfully expended. The review department is well sustained. We append notices of a few of the brief original articles.

Structure of the Cytoplasm of the Nerve Cell.[1]

Nissl's method of differential staining after alcohol hardening, which has given such an impulse to recent cytological work, is made the basis of an investigation of the relative functional value of the chromatic and the achromatic elements of the general protoplasm of the nerve cells. Dr. Lugaro comes to the conclusion that the achromatic substance is the physiologically active medium, while the chromatic elements are simply passive. The achromatic part is composed of a filar mass in the sense of Flemming, while the chromatic part which alone is stained by the method of Nissl represents an interfilar mass, and therefore the method of Nissl is absolutely negative regarding the real structure of the nerve cell.

This conclusion is based on the mode of development of the chromatic masses, their distribution in the adult cell and their relative abundance in the various processes. The fact that the chromatic substance is absent in the smallest ramifications of the nerve fibres, and is present in greater quantity and in larger masses in the larger processes of the cell and particularly in the cell body itself is regarded as evidence that it is composed either of nutritive material or of products of dissimilation. The smaller dendritic termini having a greater surface in proportion to their mass do not require any special nutritive mechanism.

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[1] LUGARO, E. Sul valore rispettivo della parte cromatica e della acromatica nel citoplasma delle cellule nervose. *Rivista di Patol. nerv. e ment.*, I, 1, Jan., 1896.

Dr. Lugaro has found in a study which we have noticed elsewhere in this number that in different functional conditions the variations of the quantity of the chromatic substance are very slight, while there is a much more constant relation between the density of the stain and the size of the cell. But there is another factor influencing the amount of chromatic substance in the cell, a "specific factor," depending on the connections of the cell or the normal intensity of its discharge. These points are illustrated by several figures of the nerve cells of both vertebrates and invertebrates. C. J. H.

The Pons Varolii of Man.[1]

Studies on human fetuses of five to seven months and on the brains of young children by several of the newer methods.

I. *Substantia grisea pontis.* These cells occupy the space between the superficial transverse fibres of the pons and the internal lemniscus, collecting in the interstices of the *fibrae transversae pontis* and the fascicles of the pyramidal tract. They are of Golgi's first type and send their nervous prolongations into the middle peduncle of both the same and the opposite side, also into the ventral portion of the raphe. These fibres are regarded as the scandent fibres of the cerebellar cortex, whose terminal arborizations lie in connection with the Purkinje cells.

II. *Collaterals of the pyramidal fibres.* These are two kinds, direct and indirect, terminating in physiological contact with the dendrites of the elements of the *substantia grisea pontis.*

III. *Pedunculus medius cerebelli.* The middle peduncles are composed not only of the ascending fibres from the *substantia grisea*, but also of descending fibres from the cells of Purkinje. Part of the latter cross the raphe to terminate in ramifications among the elements of the substantia grisea of the opposite side, part effect similar connections on the same side, others pass via the raphe to the level of the *tegmentum pontis* of the same or the opposite side. They then pass either as *fibrae arcuatae internae* or as ascending fibres of the raphe to participate in the formation of the *fasciculus medianus.* Some fibres terminate among the elements of the *substantia reticularis grisea tegmenti pontis.* To this tract the author gives the ponderous name, "direct tract from the cerebellum to the nuclei of the tegmentum pontis."

IV. *Internal bundle of the pes pedunculi.* The author has established a direct and crossed connection between the Rolandic and fron-

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[1] PUSATERI, E. Sulla fine anatomia del ponte di Varolio nell'uomo. Nota prelim. *Rivista di Patol. nerv. e ment.*, I, 1, Jan., 1896.

tal opercula of the cerebrum and the cerebellar cortex via the *substantia grisea pontis*. The latter has probably other important connections as yet unknown.

V. *Substantia reticularis grisea tegmenti pontis*. The cells of this region have large protoplasmic processes which in part join the internal arcuate fibres and in part cross in the raphe to the *substantia reticularis* of the opposite side, thus forming a protoplasmic commissure of this region. The axis cylinders of these cells in part cross the raphe, in part join the internal arcuate fibres; others, arising nearest the raphe, pass dorsally to join the *fasciculus medianus*; still others go to the *tegmentum pedunculi*.

VI. *Collaterals of the fasciculus longitudinalis posterior*. These pass to the *nucleus funiculi teretis*, the *substantia reticularis tegmenti pontis* and the *nucleus reticularis tegmenti pontis* of Bechterew.

The reader will be struck with the substantial identity of many of these results with those of Cajal upon the brains of the dog, cat and rodent, as described in *Bibliographie Anatomique*, Dec., 1894.

C. J. H.

The Influence of the Cerebrum upon the Excretion of Nitrogen.[1]

The experiments were performed on pigeons. The cerebrum was removed and after complete recovery the animal was kept fasting for from four to six days. The loss in weight from day to day and the amount of nitrogen contained in the urine were compared with the same data from unoperated specimens under the same conditions. The decerebrated pigeons lost weight much less rapidly than the normal, and the amount of nitrogen eliminated was still more conspicuously less in the case of the decerebrated pigeons. On the other hand, a pigeon which was observed on the days immediately following the operation showed a geater loss in weight and in amount of nitrogen excreted than the normal pigeons.

The author concludes that the cerebral hemispheres, at least in birds, have a marked influence in regulating the metabolic processes of the body, acting as trophic centres to stimulate the anabolic processes.

C. J. H.

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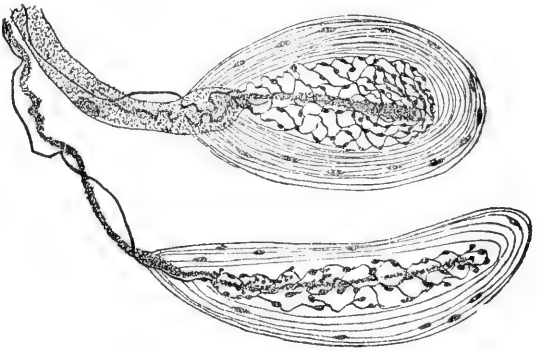
[1] BELMONDO, E. Ricerche sperimentali intorno all'influenza del cervello sul ricambio azotato. *Rivista di Patol. nerv. e ment.*, I, 2, Feb., 1896.

Nerve Termini of the Prostate.[1]

Dr. Timofeew in continuing his studies on the nerve endings of the sexual organs finds a peculiar structure in the outer connective tissue capsule of the prostate, as well as between the muscles and glands of that organ, and in the adjacent mucosa of the dog and cat.



In the cut we give a diagrammatic reproduction of one of his figures, taken from termini in the capsule of the prostate of a dog. The structure consists of two fibres, both medullated and issuing from the same nerve trunk, one of which is much the larger and enters a capsule in which it terminates in a clavate or ribbon-like expansion. The other fibre also enters the capsule and terminates in a mass of fine varicose fibres which perhaps anastomose with each other, but not with the first fibre. Both fibres lose the myelinic sheath before entering the capsule. The cut will explain the relations without further description.

C. J. H.

Demonolotry of the Nineteenth Century.[2]

The volume before us is a good specimen of the modern publishers' art and in other respects challenges criticism. It is, moreover, a book destined to create a considerable amount of interest in various circles. Unlike most recent attempts to discuss this most perplexing subject it at least claims a degree of preparation on the part of writer

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[1] TIMOFEEW, D. Ueber eine besondere Art von eingekapselten Nervenendigungen in den männlichen Geslechtsorganen bei Säugetieren. *Anat. Anz.*, XI, 2, 22 Aug., 1895.

[2] J. L. NEVIUS, D.D. Demon Possession and Allied Themes. *F. H. Revel Co.*, Chicago. $1.50.

and editor which hardly permit of an *a priori* waving of its claims. It demands a serious hearing, if for no other reason, because it claims to fairly represent the calm judgment of all but an insignificant minority of the educated occidental missionaries at present actually living among the Chinese and other oriental peoples. If this is indeed the case it may give rise to serious reflection or even to the query whether the reaction of barbarism on the missionary is not as great as his influence on the barbarism in the opposite direction.

We admit to a feeling of grave responsibility in dealing with such a work and, while we feel that scientific truth leaves us no alternative, it is hoped that the reviewer may be credited with no antagonism to the cause in the interest of which the volume was sincerely written. Even more, it is because the reviewer believes that the false views here promulgated will do great injury to that very cause that he does not feel justified in holding his hand.

At the outset it is freely granted that the entire honesty and credibility of the author and his witness is assumed in all that follows. The author has displayed not only praiseworthy industry but considerable skill in the gathering of facts and discussing their significance, and when we are forced to add that he seemed singularly lacking in critical and scientific discrimination it does not follow that the value of the facts is invalidated. Indeed the naiveté with which facts inconsistant with the conclusions are set down is sufficient check in most cases. The author is beyond the sting of criticism and we pass to a consideration of the work in detail.

In the first place we may quote the author's synopsis of the facts and conclusions reached as he closes the descriptive section of his book. (P. 143.) It will form a convenient point of departure for our review of the evidence.

"1. Certain abnormal physical and mental phenomena such as have been witnessed in all ages and among all nations and attributed to possession by demons, are of frequent occurrence in China and other nations and have been generally referred to the same cause.

"2. The supposed demoniac at the time of possession passes into an abnormal state, the character of which varies indefinitely, being marked by depression and melancholy, or vacancy and stupidity amounting sometimes almost to idiocy, or it may be that he becomes extatic, or ferocious and malignant.

"3. During transition from the normal to the abnormal state, the subject is often thrown into paroxysms more or less violent, during which he sometimes falls on the ground senseless, or foams at the mouth, presenting symptoms similar to those of epilepsy or hysteria.

"4. The intervals between these attacks vary indefinitely from hours to months, and during these intervals the physical and mental condition of the subject may be in every respect normal. The duration of the abnormal states varies from a few minutes to several days. The attacks are sometimes mild and sometimes violent. If frequent and violent the physical health suffers.

"5. During the transition period the subject often retains more or less of his normal consciousness. The violence of the paroxysms is increased if the subject struggles against, and endeavors to repress the abnormal symptoms. When he yields to them the violence of the paroxysms abates or ceases altogether.

"6. When normal consciousness is restored after one of these attacks the subject is entirely ignorant of everything which has passed during that state.

"7. The most striking characteristic of these cases is that the subject evidences another personality and the normal personality for the time being is partially or wholly dormant.

"8. The new personality presents traits of character utterly different from those which really belong to the subject in his normal state and this change of character is with rare exceptions in the direction of moral obliquity and impurity.

"9. Many persons while 'demon-possessed' give evidence of knowledge which cannot be accounted for in ordinary ways. They often appear to know of the Lord Jesus Christ as a divine Person and show an aversion to, and fear of Him. They sometimes converse in foreign languages of which in their normal states they are entirely ignorant.

"10. There are often heard, in connection with 'demon possession' rappings and noises in places where no physical cause for them can be found; and tables, chairs, crockery and the like are moved about without, so far as can be observed or discovered, any application of physical force, exactly as we are told is the case among spiritualists.

"11. Many cases of 'demon possession' have been cured by prayer to Christ, or in his name, some very readily, some with great difficulty. So far as we have been able to discover, this method of cure has not failed in any case, however stubborn and long continued, in which it has been tried. And in no instance, so far as appears, has the malady returned if the subject has become a Christian, and continued to lead a Christian life."

A few words in passing upon this summary. The admission of 1 is significant and is fully borne out by the facts adduced. These so-called possessions are not in any material way different from phenomena with which modern pathology is dealing every day at home with no doubt of their pathological character. That they have been generally referred to devils is as forcible an argument as it would be to adduce the universal belief that scrofula was due to the evil eye in a modern medical consultation. We might drop the matter right here and would be content to do so if convinced that all our readers were familiar with the state of scientific opinion. We have, then, not a peculiar set of phenomena but a familiar set in peculiar setting which alone warrants its selection for special study. Our author does not hesitate to suggest (p. 182) that "the unscientific Chinese were, so far as this subject is concerned, more careful observers of facts, and more correct in their conclusions than many who have been leaders of public opinion in our times;" the direct objective being here modern pathologists. This is a remarkable statement which becomes more remarkable with every illustration of the scientific attainments of the oriental observer and healer.

The symptomatic complex indicated in the following sections contains nothing novel in any way, but the strange circumstances and the implicit faith of the barbarians in the supernatural character of the manifestations very naturally produce a strong impression on the visitor. The author was chiefly struck by the apparent transformation of the personality during such attacks, yet he is not entirely ignorant of the fact that a change of personality is characteristic of well-known nervous maladies. It is gravely stated that the possessed shows supernatural powers of speech and gaining information. There is, however, no case given where such powers are proven. It is true that under the pressure of the disease the patient may seem to speak with tongues, but when the evidence can be thoroughly sifted such cases usually find their true place among familiar facts. A case in point now occurs to the writer. The wife of a prominent theological professor, herself a woman of great strength and refinement of character but not well-versed in the German language, awoke one morning and to her own great distress and the astonishment of her family was utterly unable to speak a word of English but made her wants known in German. Her husband was even less familiar than she had hitherto been with that language so that she was for the most part unintelligible. The good Doctor, in narrating the circumstances, stated that she spoke fluently, but admitted that neither he nor she were in a condition to gauge the correctness of the language. This cultured lady had never had a mastery of the spoken tongue but suddenly, without apparent cause, lost the speech of her birth and entire life and seemed to have miraculously acquired a new faculty. My friend, as a sensible man, did not seek to exorcise a demon or even send for a doctor, but employed the expectant method until the curious nervous kink straightened out of itself, never, so far as known, to reappear. If this circumstance, which is known to very few, had taken place in an ignorant community, the belief in possession would have been absolute and the sufferer, if not of unusually well balanced mind, would have been tormented into permanent delusions or worse. Again, in the case of the writer it has happened while studying language and in a stage where ordinarily the act of composition was painfully tedious, that, say during an early morning doze, he seemed suddenly endowed with a gift of tongues and rolled off sentence after sentence with the greatest ease and apparent accuracy. The neurological explanation of such phenomena is not difficult and, if it were, the appeal to demoniac possession would add but another and more insoluble problem. In one case cited by the author the subject seemed to be able to describe a distant country and her power was accounted miraculous, but the more than usually accurate reporter adds that her descriptions were only correct in the general outlines and not in detail and that she might have picked up the facts used from other sources.

If the author had lived in this country during the last twenty years it is unlikely that he would have considered the resemblance of the oriental table-tipping performances to those which ran their course here as evidence in favor of their spiritual nature.

One point requires further notice. The morbid personality is usually *worse* than the normal. Does this seem remarkable? We think it is only what should be expected. In the life of every person not utterly depraved there is a constant struggle against what are to him temptations. The even trajectory of normal life is the resultant of conflicting forces of which some are (to the subject) bad or malign. This is quite apart from any absolute moral system. In neurotics these antimonies are doubly strong. When, then, the one set of mental forces are switched out of circuit the other is likely to be immanent. The ruling or dominant forces are just the ones to be unhorsed for the reason that they are so largely inhibitory while the other set is chiefly intrenched in the elementary physical nature.

Before passing to the evidence collected by the author let us note something of the setting of the facts.

"It will be observed that nearly all the incidents related are given on the testimony not of missionaries, but of native Christians—mostly native pastors." (Introduction, p. v.) The native Christians continue in this belief. (P. vi, and *passim.*)

"Antecedently to any knowledge of the New Testament the people of North China believed fully in the possession of the minds and bodies of men by evil spirits." (P. iv.) The natives at once recognized the identity of the biblical possession with the phenomena about them.

Our witnesses are, then, filled with a prepossession and it would never enter their minds to seek any other than the demoniac explanation, this "belief being a part of that animism, or spirit worship, which has existed in China—as in many other countries—from the very beginning of history or tradition." (P. iv.) They do not regard the phenomena of possession and exorcism "as anything strange or remarkable." (P. 35.)

Such are the witnesses that are regarded by the author as "more careful observers and more correct in their deductions" than modern pathologists. We cannot expect the writer under the limitations necessary to his work to exhibit a familiarity with the recent discoveries in hypnotism but we must at least concern ourselves with the evident bias of writer and observers.

Again, a belief in exorcism is shown to be universal. The detailed account of the exorcists (p. 68-71) is very full and instructive. The belief that these professional mediums, whether Confucionist or Taoist, have a real power to drive out demons is as implicit as that in the spiritual nature of the manifestations. If the universal belief of these heathen is to be taken as irrefrangible evidence we must also believe in the supernatural power of as pitiful a set of mountebanks as ever disgraced the name of man. We must believe in charms, in amulets and witchcraft. In other words, the learned author and by implication the whole body of occidental missionaries wish us to abrogate whatever of moral progress has been made by civilization and return to the beliefs and practices of medieval superstition. Probably the author did not follow his argument to its legitimate conclusion but there is no logical stopping place short of that indicated. The exorcists are supposed to be the special aversion of the spirits and "never venture anywhere without having charms, talismans, and all kinds of abracadabras with them." Armed with a black mule's hoof and a black dog's blood these practioners do, nevertheless, succeed in going about to very good purpose. "She spends her time going about among the villages in the neighborhood telling fortunes, and healing diseases, and in this way makes a good deal of money" (p. 37). The phenomena attending séances are exactly such as those with which we are too well acqainted here. "Tables are turned, chairs are rattled, and a general noise of smashing is heard." Even Slade and his slate have their counterparts, "the pencil moving of its own accord" (p. 69). The effect of the mysterious is indubitable. We all recall that no less a person than Professor Zöllner was mystified by Slade and induced to commit himself to absurdities which appear in high relief since the fraud was confessed. That the oriental exorcism is associated with vulgar conjury and legerdermain is evident throughout these pages and the skill of oriental jugglers is almost past belief. That, on the other hand, there is a certain amount of honest belief in the powers of spirit on the part of the profession is also evident. A large class of semi-professional healers occupies the same place as the "Christian healers" and "faith healers" of our own locality. Almost while these lines are being penned a new Man-Christ is touching and prescribing for all manner of diseases and as many as are touched are made whole. Even handkerchiefs acquire curative power by being blessed by this ignorant peasant. A thriving trade is being driven in counterfeit blessings and advanced positions in the line at his door have sold for seven dollars. But it is not necessary to seek isolated cases like that of Francis Schlatter when any patent medicine circular will reveal a long roll of clerical attestations to absurdities too patent to deceive a healthy child. The love of, and belief in the marvelous is too thoroughly ingrained to yield easily to judgment or authority.

Prominent among the facts forming the background of these appearances is the evidence of neurotic predispositions in the subjects described.

One curious fact familiar to all physicians seems to mystify the author, i. e., that neurotic individuals are generally the reverse of feeble in appearance. They generally look younger than others of the same age and seem quite well to the untrained observer. Indeed it is one of the special inconveniences of nervous disease that it is hard for his friends to refer the irritable and distracted moods of the sufferer to a diseased condition. He gets credit for pure malignity where he perhaps deserves only profound sympathy, he himself frequently taking the same view.

So much for the background, but we must notice that the author is at great pains to insist that there is no conceivable bias in favor of the demon theory and the resulting practice of exorcism on the side of the missionary. In fact, we are told that they are at first skeptical. How has it escaped the writer that the missionary is under the strongest of all inducements to accept the current interpretation? It is, however, a common experience that one should be unconscious of the most powerful motives influencing his belief and we need not impugn the honesty of such an one in insisting that this motive is patent to every outside observer. The exorcism of the natives is an integral part of their religion and is adopted by all sects alike. When Christianity enters the field it must at once compete with these sects in this most practical matter. Since the function of religion is to control the spirit of evil, that must be the best religion which most successfully combats these manifestations of satanic power. The author expresses surprise that the natives eagerly seize upon the accounts of New Testament possession and need no suggestion from the missionary to turn them to practical account. The result is what one would expect. Grant, as we must, that the native doctors are often successful with their burning pills on the nerve plexus at the roots of the nails, and that the native conjurers are also frequently able to banish the disease by their incantations, it would be expected that the strange message from a land beyond the realm of dreams should create the conditions for deliverance, nor is it astonishing that the complete change in mental attitude and the saner methods of life involved in embracing Christianity should cause, in many cases, a permanent cure. Even a much less significant change is often sufficient in practice. "The number of those who for this cause have become Christians is very great." (P. 51.) The missionaries must be much less or more than human if they are uninfluenced at least unconsciously by this unexpected and powerful means to reach the otherwise inaccessible heathen. Who shall determine whether this is not a providential opening? Be this as it may, it would seem unnecessary to degrade occidental humanity to the same depths of superstition and we cannot applaud the attempt.

Fifteen cases are presented from China and we must give up our plan of analysing them and do so the more willingly that they present nothing novel or especially pertinent not already noticed. In the spiritualistic career the fortune of the experimenters often mysteriously disappears. The afflicted is incidentally shown to have been a gambler and profligate, etc. The author explicitly denies that there is any tendency to epidemics but there is evidence, even in the few cases given, of contagion, i. e. that the influence of others is felt not only in producing but in determining the form of the attack (p. 37). The rhythmical form of expression in such cases is as old as history and the author himself notices the resemblance of the utterances of these modern pythonesses to " the meaningless chants heard in Buddhist temples." He may not have known of the frequency with which such facility of versification appears in the exalted states of mania. It will even be recalled that the habit discoverable in Shakespeare's characters of dropping into mongrel rhymes at the critical moments has been seriously defended on the ground that it is a common tendency of overwrought minds to spend and distract themselves in poetical expression.

With the second or theoretical part of the book it is difficult to speak patiently, perhaps unnecessary to speak at all. We are told that the distinguishing marks of demoniac possession are alterations in personality. We can form only a vague guess as to what is meant by personality, but, whatever it is, it remains certain that the vast majority of the insane would by this law be regarded as possessed. By a simple application of this conclusion it would appear that dements with morbid changes in the cortex (as easily detected by the microscopist as small pox pustules in the skin) should be treated as possessed and cured by exorcism.

Cases are now well known in which an insane person has two different states or " personalities " in one of which he has one set of mental and moral attributes, and in the other, along with certain obscure but measureable changes in circulation and other physiological functions, displays an entirely different set of mental and moral peculiarities. In one case he is intelligent and speaks fluently—is crafty and excitable, while in the other he is stupid and speaks a different language. Nor are we wholly at a loss as to the physical cause of this double manifestation. We find, perhaps, that he is left-handed in the second state but right-handed in the first. We learn that he was left-handed in his boyhood in Wales but learned English and the use of the right hand later, receiving an education in English. With abundant evidence now at hand that only one side of the brain is concerned with speech, and that the side corresponding to the educated hand, we have a right to suggest that both halves of this man's brain have been modified, the one in the Welsh or left-handed, the other in the English, right-handed way. We cannot follow this line further, but it suggests a reasonable ground for the most difficult phenomena of hypnotism. The author's distinction between the pathological and psychical theory is arbitrary. We think a proper appreciation of the dignity and sphere of the soul would make one glad to see in the driveling lunacy of the class of phenomena here discussed matters for the alienist rather than the theologian. It was a very true word in the author's preface : " Some of the readers of these pages will in all probability be disappointed in finding the characters and doings of spirits much less interesting and creditable than they are represented in the familiar writings of Milton and Dante." This in itself would be sufficient refutation of the claim to most candid readers, but no explanation is vouchsafed.

We ought perhaps to accept the Chinese idea that the demons are simply the souls of the departed who have not been so fortunate as to appear in the imperial edict deifying them off-hand.

Of the question as to the relation of the described phenomena with those of New Testament times we say nothing, though it forms a large element in the book. But we have done. That the views presented should be accepted by scientific men is impossible; that they should gain acceptance in the circle of religious enterprise and education would be very unfortunate as it would tend to perpetuate and widen a very unnecessary breach where the fullest harmony and sympathy is important. C. L. H.

The Growth of the Brain.[1]

The present volume is a very worthy addition to the Contemporary Science Series, for in its 19 chapters containing 368 pages, there is a clear, concise, and very readable statement of the most interesting facts regarding the growth of the brain.

The author gives in his first chapter an introduction to the study of growth and sums up the laws which seem to govern it. The gradual increase of the weight of the human body is represented by means of diagrams, the comparison between the male and female being well brought out. The next chapter gives with greater detail the relative increase of different parts of the body, showing the proportion between weight-increase and increase of stature. In the fourth chapter the weight of the brain and spinal cord are treated. The point is clearly made that in taking brain weights other things than nerve cells are often weighed, as for instance the membranes, pia and dura, the blood vessels and cavities with their fluid contents; therefore there is bound to be a certain discrepancy in the weights made by different observers if the same methods of weighing are not followed. This the author claims has not been done, and much of the material now at hand is consequently of little value in making deductions. In trying to arrive

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[1] The Growth of the Brain, by HENRY HERBERT DONALDSON, Professor of Neurology in the University of Chicago. Imported by *Charles Scribner's Sons*, New York, $1.25.

at general conclusions Professor Donaldson believes in grouping the statistics, for "age, stature, sex, bodily weight and race" are all modifying circumstances. He concludes that there is a marked constancy in the *percentage values* of the subdivisions of the encephalon of all ages, all statures, and both sexes.

Thus after maturity the male encephalon and all its parts are larger than the female. With increasing age there is a decrease of the weight of the encephalon and all its parts, and for the same age and sex decrease in bodily weight is accompanied by by a decrease in weight of the encephalon as a whole and in all its subdivisions. In this respect the two sexes are similar.

In chapter V, on Increase of the Brain in Weight and Variations of the Cranium in Capacity, the suggestive fact is brought out that the greater part of the growth of the brain takes place before any of the formal educational processes have begun. In speaking of the weight of the brain of non-European races, quotations are made from Hunt's observations upon weights of the brains of mulattoes and negroes, in which he shows that the negro brain is uniformly less than the European, and in those mulattoes with a mixture of less than half of white blood, the result is even below the negro average, while in a mixture of over half white blood, the average is between that of the negro and of the white. In the "Variations in Brain Weight" the author states that, while the heaviest brains belong to the European races and the lightest to the Australians, yet it is quite impossible, even in a condensed series, to harmonize intermediate groups with the theory that brain weight and culture as we measure it, are closely correlated.

In discussing the brain weights of eminent men a number of interesting tables are given, showing that it would appear that greater brain weights are more frequent among eminent men even when these are compared with groups of men of ordinary intelligence but of large stature. The fact is noted however that most of the comparisons have been made between "eminents" and "ordinaries" or even "criminals," while the brains of reputable and successful and professional men have not been weighed. The insane present encephala that are very slightly less than the normal in absolute weight; while the difference between the sexes is less marked than in the sane.

Chapter VII gives a good summary of the nervous elements according to recent modes of interpretation. The next chapter has an interesting outline of the development of the nerve elements, a subject that would be of value to pedagogues. Some very important and interesting collections of data are brought together in this chapter, the author stating that the enlargement of the nervous system is due, first to the increase in number of the neuroblasts formed, and secondly to their increase in size. He thinks that in the growth from the child to the adult the increase in brain weight is due to the development of the medullary substance about the neuron.

In the chapter upon the "Architecture of the Central Nervous System" at maturity, there are given those anatomical features of the brain that are familiar to most students of anatomy, but in addition there are a number of interesting correlations that no mere text-book of anatomy ever gives.

The chapter upon "Changes due to Growth" tells us how little we know upon this important subject.

Chapter XIII discusses localization of function giving the main well known facts upon the subject. The "Physiology of the Nerve Cell" and "Physiological Rhythm" present some of the results of later psychological work; while the chapter on "Fatigue" gives some of the observations of Hodge and Vas, in which the author is inclined to lay more stress upon Hodge's work than upon the experiments of others that have given different results. In the "Education of the Nervous System" there are a number of sound generalizations.

This book is to be heartily recommended to the student and educated layman. While it may at times be difficult for the latter to follow all the mathematical details, yet a persistent reading will give him a broad grasp of many important and useful facts.

SMITH ELY JELLIFFE, M. D.

Recent Studies in the Forebrain of Reptiles.[1]

The latest number of this series, which comparative neurologists have learned to prize as much for its appreciative summaries of the work of others as for the well-digested results of the author's own patient studies, is just at hand. Among recent writers Dr. Edinger has the honorable distinction of never slurring over or consciously misrepresenting the work of others. We are often obliged to seek from other sources the evidence of the large share the author's own work has had in attaining the results accredited to others. An error is always frankly admitted and the genial Doctor seems to feel that a personal favor is conferred by the writer who is fortunate enough to set him right. It is

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[1] EDINGER, DR. L. Neue Studien über das Vorderhirn der Reptilien. Untersuch. ü. d. vergl. Anat. des Gehirns, 3. *Frankfurt*, 1896.

little wonder therefore that views so formed and so expressed have great weight with his compeers.

It will be impossible in the space at our disposal to recapitulate the abundant material offered by this paper. Edinger corrects the mistake made in earlier papers of failing to distinguish olfactory centres of the first and second orders, or (to use his own nomenclature) *Riechfeld* and *Ammonsrinde*. This whole subject has been elaborately discussed by Elliot-Smith, Meyer and the writer. About ninety series from a wide range of groups were employed by Dr. Edinger in his study and the variety of methods was adequate to insure mutual supplementation. The nomenclature used is modeled on that of the recent report of the German Nomenclature Commission. Tracts are named as far as possible by compounding their termini. Instead of using the word lobe to apply to cerebral regions Edinger seeks to avoid misleading analogies by such terms as "cortex medio-dorsalis." Although the olfactory fossa is mentioned, we miss any reference to the Jacobson's organ fibres. In the basal lobe three parts are distinguished as striatum, mesostriatum, and epistriatum, terms, however, which may be open to the charge of suggesting premature homologies.

In the discussion of the histology of the cortex the results are similar to those of Cajal. The anterior mantle commissure is no longer as formerly homologized with the callosum but with psalterium fibres as a "*commissura pallii anterior*." We regret that the ambiguous terms anterior and posterior should be given greater currency. It is to be noted that in some groups the anterior commissure contains mantle fibres so that the ambiguity is doubled.

The following tracts are identified with the olfactory apparatus: The *radiatio olfactoria*. This is the radix lateralis of other writers. To this term the author objects on the ground that it suggests a homology with the roots of cranial nerves. The criticism is well-founded but we are surprised to see the discovery of the true relations attributed to Cajal. We had supposed that the origin of the radix fibres in the cells of the bulb had long been recognized. Certain it is that a good hæmatoxylin stain reveals this relation as well as the Golgi impregnation. We have thus demonstrated it in the Amphibia. On the next page the same tract seems to be formally named *tractus bulbo-corticales*, though a part of the fibres end in the cortex of the lobus olfactorius and part in the corpus epistriatum. Thus does each part rejoice in, not one, but often two new names from the same source—thanks to the efforts of the German Nomenclature Commission. The pero of Wilder, which the author has hitherto professed himself unable to differentiate, appears as the *formatio bulbaris* which "results from the union of the olfactory nerve fibres with the processes of the ganglion cells." We have devoted so much space to this structure and its relation to the sheath formation and method of termination that it is with some surprise that we note the meagerness of detail and reserve as to well authenticated results.

We do not gather exactly what is meant by the lobus olfactorius—in figure 5, it would seem to be the pes bulbi, but the description seems to make it plain that the frontal protuberance of the cerebrum forming the support of the bulb is intended. The *tractus cortico-epistriaticus* consists of fibres rising in the lobus near the termini of the radiatio. From the area olfactoria arises the *tractus olfactorius septi* which Edinger identifies as our radix medialis. It terminates in the cortex of the hippocampal region—"Ammonsrinde." The term "area olfactoria" is applied to an enormous extent and is divided into the *nidulus occipitalis*, *tuber thæniæ* (pyriform lobe) as well as the post-rhinal lobe, to which it would seem to directly apply. The various bundles connecting with the thalamus are all included in the thænia thalami, including *tractus olfacto-habenularis* and *tractus cortico-habenularis*. It seems to the reviewer doubtful whether we are at present justified in referring all these fibres, with no more to do, to the olfactory apparatus.

If we understand correctly, Dr. Edinger accepts the suggestion that the epistriatum is an invaginated cortical area. It is to be regretted that some comparisons were not made with the basal lobe of birds as described by Turner, who made out similar divisions and even found an invaginated cortex in somewhat similar relations.

We are glad to note that the author has so far modified his earlier views as to recognize the probable existence of a tract connecting the optic centres with the cortex, "Sehstrahlung aus den Opticuscentren zur Rinde."

Thus the earlier position that the cortex of reptiles is wholly given up to the olfactory function and its associations is somewhat modified but appears in the following form: "Nur lässt sich sicher bestimmen, dass der grösste Teil der Reptilienrinde mit dem Riechapparat Zusammenhängt."

It is indeed a most creditable achievement to have called attention to the psychogenetic significance of the preponderating position among the cortical stations held by those of smell, but we respectfully repeat our statement, made on several earlier occasions, that it is not correct to attribute an exclusively osmatic tone to the cerebral activities of the Sauropsida or even the Ichthyopsida. The vast complexity of cortical histology providing, as Edinger himself recognizes, for wonderfully complicated coördinations, even did we not know of visual tracts to the cortex, would suggest a greater diversity of function. We fail to understand why a connection between the homologue of the geniculatum and the cortex is overlooked.

The present work is well adapted to serve as a point of departure for all subsequent comparative studies of the cerebrum.

C. L. H.

Modifications of Nerve Cells in Different Functional States.[1]

A brief historical introduction serves to throw into strong relief the utter disagreement existing between the results of almost all of the investigators who have thus far studied this question. The classical experiments of Vas upon the cervical sympathetic ganglia were repeated in 1894 by Gustav Mann (cf. the review in Vol. V of this Journal, p. xxxii) and again by Lugaro in the paper before us. The latter author feels that he has removed many of the contradictions of the previous investigators and explained the others. He calls attention to the fact that the so-called resting cells of other authors are by no means such but that to the fatigue of normal functioning before death must be added the intense discharge accompanying their excision as well as those changes occasioned by the action of the fixing reagent between the time of immersion and the time of cellular death. Another source of error is the subjective one arising from the difficulty of estimating the relative sizes of the normal and fatigued cells when the sizes of both sets vary within wide limits. The former difficulty was met by killing in various ways, particularly by comparing cells fixed by rapid excision and treatment with the fixing fluid with those taken several hours after death from an animal killed by rapid chloroforming; the latter difficulty, by carefully counting all of the cells from many average fields from each of the two sets of preparations. In each ganglion the longest diameter of 1000 elements was measured.

The results of these observations are presented in the form of a series of curves. Cells of ganglia taken from the body five hours after death when compared with normal cells (taken from the body by vivisection) show a decrease in size 4.95%. Elements electrically excited for a time which does not exceed a half hour show an increase in size as compared with the normal. This increase is at the maximum of

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[1] LUGARO, E. Sulle Modificazioni delle Cellule nervose nei diversi Stati funzionali. *Lo Sperimentale*, XLIX, 2, Aug., 1895.

6.69% with an excitation of five minutes. If the excitation is continued longer than a half hour there is a strong diminution in size of the cell. After excitation of one hour the diminution is .84%, after three hours 11.5%, after six hours 16.53%.

Synthetic curves based upon the measurements show that the size of the cell rapidly increases during moderate activity, but under prolonged stimulation diminishes far below the normal; that the size of the nucleus follows the same law but to a less extent and less abruptly; that the size of the nucleolus increases more rapidly than the size of the cell and that it diminishes under prolonged excitement much more slowly. The author concludes that the size of the cell is acted upon by two tendencies, one positive, activity, the other negative, fatigue. Letting d represent the dimension of a cell, n the normal (average) size, a the alteration due to activity, and f that due to fatigue, d will vary as expressed in the following equation:

$$d = n + n\ (a - f).$$

The tardy alterations in the nucleus are regarded as consecutive to those in the cytoplasm. The nuclei, contrary to Hodge and Mann, do not wrinkle.

The experiments are thus summarized:

1. The activity of the nerve cell is accompanied by a state of turgescence in the protoplasm of the cellular body.

2. Fatigue causes a progressive diminution in the size of the cellular body.

3. In moderate degrees of activity, while the cytoplasm swells, the nucleus suffers no modification of volume.

4. When the activity is continuous and of long duration, the nucleus suffers modifications analogous to these of the cellular body, but less intense and slower.

5. The quantity of chromatic substance in the cellular body varies always as an individual character in proportion to the size of the cell. Nevertheless it is probable that the first phases of cellular activity occasion a slight increase in its amount, the last phases accompanying fatigue, a diminution and a more diffuse distribution.

6. The activity of the cell occasions in the nucleolus an increase in volume which gradually yields to the reducing action of fatigue.

Following these experiments are some very interesting theoretical observations in which attention is called to the fact that if we extend the knowledge acquired of the changes in form of the body of the cell to include the cellular processes also, assuming that the processes elongate during functional activity and shorten during fatigue, we have taken a long step in the direction of a knowledge of the physical basis of the corresponding emotions, as well as of the physiological facts associated with exercise and fatigue. C. J. H.

The American Lobster.[1]

Six years ago Dr. F. H. Herrick was invited by the United States Commissioner of Fisheries to prepare a monograph on the Biology of the American Lobster. A systematic investigation was begun and in this final paper, which has been awaited with considerable eagerness by the biologists, we have a summary not only of the author's own researches, but of practically all that is known concerning the life history of this species. The work makes 252 pages quarto and is accompanied by 64 full page plates, many of them colored to life, illustrating very fully the development and gross anatomy. The details of the fine histology are not entered into except in a few cases.

The practical and scientific value of the work are both very great. It is not common to find both of these features so well represented in a single monograph.

One of the points of greatest practical importance, bearing on the problems of the artificial culture of lobsters, is the chapter on The History of the Larval and Early Adolescent Periods. The account of the Embryology of the Lobster is more meager than we should have expected from the fact that the author has devoted so much attention to this subject and has already published several short papers. He makes no attempt to give a detailed account of the embryonic history, but a few notes merely on the early phases of development.

From our standpoint the topics of especial interest centre about the descriptions of the habits and organs of sense of the lobster. The breeding habits, habits of migration and feeding and the like are quite fully detailed. In its native haunts it shows considerable agility in avoiding its enemies and cunning in the capture of its prey. The senses of sight and and hearing are probably far from acute, but it possesses a keen sense of touch and of smell and probably also a sense of taste. It is also quite sensitive to changes of temperature, this being the factor in the environment which is in the main responsible for the periodic migrations of the lobster.

Experiments made with various stimuli, such as electricity, heat, weak acetic acid, ammonia gas and clam juice, led to the conclusion that

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[1] HERRICK, FRANCIS HOBART. The American Lobster: A Study of its Habits and Development. *Bulletin U. S. Fish Commission*, 1895.

all or nearly all of the appendages react strongly to chemical stimuli and in many cases the surface of the body is capable of receiving and responding to stimuli of various kinds. In some places the skin of the lobster with its shelly covering seems quite as sensitive as that of the frog. The organs by which the stimuli are conducted through the chitinous shell must be either the hair pores or the glandular ducts. The author decides in favor of the latter.

C. J. H.

Pain in the Pectoral Region Sympathetically Accompanying Irritation of the Forearm [1]

The patient, a fireman, developed very peculiar symptoms, probably as the result of a fall and injury of the back and elbow. Constant though unequal pain is felt in the right shoulder on the right side of the back at the level of the seventh dorsal spine. On the right side of the chest, in front, there is an area bounded laterally by a vertical line from the axilla to the sixth rib and mesially by a line laterad of the right nipple. The pains felt here have a burning or tearing character. Beneath the right nipple is another painful spot which only announces itself after exertion, as rapid walking or turning in bed. The posterior aspect of the right arm also is subject to pains, generally induced by pressure over the radio-humeral articulation. The area does not include the fingers but extends upon the dorson of the hand. Bending the elbow causes severe pain, as does movement of the wrist, though there is no swelling of the joints.

A touch on this arm area is felt in the pectoral area, as well as in the arm; firm pressure over any part of the arm area, except the pain centre over the joint, causes severe tearing pain in the pectoral area. For years the patient had been in the habit of sweating profusely with the right side only though when at work all parts perspire alike. A fall a week or so before the symptoms appeared injured the elbow and back and there seems to have been a blow of a less violent sort on the chest. The author thinks this a case of sympathetic neuralgia but there is difficulty in discovering the nervous connections necessary to satisfy the hppothesis.

C. L. H.

Corrigendum.

On page ix of this issue in the review of Professor Kölliker's article, line 7 from the bottom of the page, insert after "habenulae," "and ends in the ganglion interpedunculare."

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[1] MUNRO, T. K. *Brain*, IV, 1895.

LITERARY NOTICES.

The Development of the Brain and Sense-Organs in Elasmobranchs.[1]

This well-prepared paper is somewhat misrepresented by its title, for it is in reality, in so far as concerns the original portions, a study of metamerism of the brain and the origin of certain sense organs based on embryos of *Squalus acanthias*. The questions to which this paper addresses itself are sufficiently ambitious, being such as the following: (1) What was the primitive condition of the nervous system of vertebrates? (2) What were the number and nature of the primitive neural segments entering into the brain? (3) What has been, in general, the line of modification along which they have been converted into the brain? (4) What were the early steps in the differentiation of the sense-organs? This is certainly a program calculated to awaken high expectations and it is no detraction from the genuine excellence of what is offered to admit that the materials and their employment are undoubtedly inadequate to its fulfilment. The paper does, however, give very useful summaries of the historical development of those phases of the subjects which are taken up.

The earlier part of the paper is occupied with the problem of metamerism. The author apparently agrees with McClure in minimizing the segmental value of the cranial nerves because of the uncertainty due to the degenerations of certain branches and even entire nerves. This may appear inconsequent when he, at the same time, explains the segmentation of the tube as due to the cranial nerves. This criticism is not necessarily valid, however, for it may be true that the segmentation of the brain was originally due to the concentration of nervous matter adjacent to the point of development of the segmental nerves and yet this segmentation might persist in an early stage of animals in which the subsequent development processes had been diverted. In other connections, however, the author fails to avail himself of this possibility. Professor Locy does not admit that the segmental divisions of the middle germ layer are primitive. He accepts

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[1] Locy, Wm. A. Contribution to the structure and development of the vertebrate head. *Journ. Morphology*, XI, 3, 1895.

the writer's suggestion that "if neuromeres once existed in the fore-brain they would be visible only at an early stage. . . The so-called fore-brain neuromeres differ from those of the medulla in involving only dorsal structures." He also apparently succeeds in resolving the the discrepancies between Froriep's account and that of other writers.

Fifteen pages are devoted to original observations on metamerism in *Acanthias* and both descriptions and plates are admirably done. Especial praise should be awarded the plate of photographs of the very young stages which are particularly valuable, as also the dissections reproduced in plate XXVIII. The constancy of the phenomena in extremely early stages in various groups serves to justify the present writer's prediction and to furnish a new motive for a re-canvass of the subject. The suggestion that they are artifacts is satisfactorily disposed of, though it is less clear that the node-like structure sustains a positive and constant relation to the definitive structure of the brain. Do they look backward rather than forward?

This segmentation is said to be independent of mesodermic influence and, as proof of this, the fact is cited that it precedes the mesoderm segments. It should be noted, however, that if it be conceded that the segmentation is not due to direct mechanical influence and so really has morphological significance, as the author claims, then we must look for the cause in a state when the head was fully segmented and mesodermic influence then could readily be appealed to. This the author would doubtless agree to.

In *Squalus* he recognizes as represented in the ontogeny at least fourteen paired neural segments. The assignment of neuromeres to the sense organs and nerves is as follows:

I.	Olfactory.	Fore-brain.
II.	Optic.	
III.	Pineal sense organ ?	
IV.	Oculo-motor.	Mid-brain.
V.	Trochlearis.	
VI.	"Anterior" (cephalic ?) root of V.	Hind brain.
VII.	Main root of V.	
VIII.	No nerve.	
IX.	Facialis.	
X.	Auditory.	
XI.	Glossopharyngeal.	
XII.	Vagus.	
XIII.		
XIV.		

The segments are serially homologous. In *Squalus* the optic vesicles are the first rudiments of sense-organs to appear and originate before the separation of the fore-brain. Their peculiar form has led to their being long overlooked. The curious segmental sensory patches which were described by the author as accessory optic vesicles arise in in a way similar to that of the eyes. They first make their appearance when the neural plate is broadly expanded. Four pairs of such organs, at least, are noted, the cephalic pair forming, as is claimed, the pineal body. They are embryonic and transitory structures and are thought to point back to a multiple-eyed pre-vertebrate condition.

A review of the literature upon the pineal seems to the author to lend force to the suggestion of a multiple-eyed ancestor of vertebrates. The results " go to show that there are two distinct outgrowths of the thalamencephalon of Petromyzon, Teleosts and Lacertilia." The cephalic one is that developed into the pineal eye in front of the epiphysis in Lacertilia, and corresponds to Hill's anterior vesicle in teleosts.

In passing, it seems that a halt ought to be called in the unjustifiable introduction of untranslated descriptive terms from the German. " Zirbelpolster " is not an English word and is not a desirable addition. If a popular term is needed it may be easily translated but it is much better to substitute a Latin equivalent. Our European friends should also realize that the scientific world cannot consider an organ properly named and presented for acceptance until a name has been proposed conformable to the common nomenclature of the scientific world.

The auditory organ is briefly discussed and its relation to the lateral line system recognized.

The paper supplies many details that have been wanting hitherto and has several pregnant suggestions, but its chief value is in the completeness and apparent accuracy of illustration.

C. L. H.

The Sensory Physiology of Actinians.[1]

Recognizing the growing importance of the comparative physiology of the nervous system, especially among the lower invertebrates, Dr. Parker has undertaken a series of experiments on the common actinian of the Atlantic coast, *Metridium marginatum*. In taking food, two kinds of responses are met, ciliary and muscular; only the latter shows evidence of nervous control, Numerous experiments illustrate the slight physiological centralization in the nervous functions of these organisms. Each tentacle acts like an independent organism. The curious fact is observed that the cilia on the lips reverse their motion

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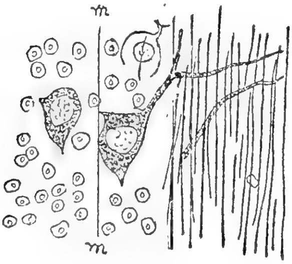
[1] PARKER, G. H. The Reactions of Metridium to Food and other Substances. *Bul. Museum Comp. Zool.*, XXIX, 2, March, 1896.

during the act of swallowing. The usual stroke of these cilia is in a direction away from the mouth, as is shown by the motion of particles of carmine or other insoluble substance. But when a piece of meat or a drop of meat juice touches these cilia they reverse their motion after an appreciable latent interval.

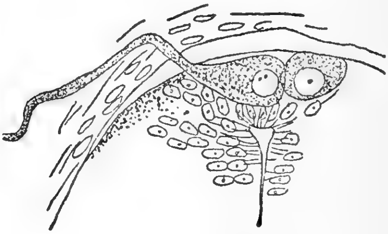
C. J. H.

The Histology of the Myelon.[1]

The "Reissner's" or "Dorsal Cells" of the Cord. Many years since, peculiar cells were noticed in the dorsal portion of the spinal cord of Petromyzon. Reissner described them in 1860, and, in 1877, Freud succeeded in tracing their axis cylinders into the dorsal root, though it has since been shown by Beard that they do not originally emerge with the sensory fibres and are of a kinesodic nature. Rohon, in 1885, detected similar cells in the trout and they have since been noticed in the embryonic stages of other Gnathostomata. According to Studnicka, however, these cells, though distinguished from adjacent elements by their great size, are not homologous with the "colossal cells" of the spinal cord of Amphioxus. The latter are median in position and are sparsely distributed; their axis cylinder passes laterad and arches ventrad and, after crossing to the opposite side, extends toward the head. Some of their smaller processes were traced by Koelliker into the dorsal roots. Respecting these Studnicka suggests that they may probably be regarded as inherited from some invertebrate predecessor. He claims that the "medium-sized" cells of Amphioxus correspond with the Reissner's cells of higher forms. These are bipolar,



Horizontal longitudinal section of spinal cord of Ammocetes.



Reissner's cells from dorsal region of spinal cord of Pristiurus.

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[1] STUDNICKA, F. K. Ein Beitrag zur vergleichenden Histologie und Histogenese des Rückenmarkes. *Sitzb. Köngl. böhm. Gesellsch.*, 1895.

occupying a lateral position with respect to the central canal. One of the main processes (Studnicka calls them both axis cylinders) passes in a longitudinal direction, while the other emerges with the dorsal root. If this identification be correct Reissner's cells occur throughout life in Amphioxus, Petromyzon, Protopterus, Triton, and certain teleosts, while in the selachians and ganoids, as well as some others, they are embryonic and transient.

In *Lophius* it will be remembered that they have a very restricted but specialized occurrence. The form is generally crescentic with the concavity mesal. One of the processes crosses to the opposite side of the cord and passes either toward or from the head. The other or true axis cylinder originally passed directly ectad and innervates the myotome, though in some cases it associated itself with the dorsal root. Burckhardt's "Randzellen" described in Protopterus are found to occur in Petromyzon also, but they have nothing to do with the Reissner's cells. The term selected by Studnicka, "Hinterzellen," suffers from ambiguity common to the German terms of direction. If we substitute "dorsal cells" there is a possibility of confusion with cells of the dorsal cord so that the familiar term Reissner's cells may still be employed.

In a second paper[1] the same author describes the expansion of the canalis centralis found at the caudal extremity of the cord of Amphioxus and the Cyclostomata and differentiates it under the name "Sinus terminalis" from the "Sinus sacralis" of acaudal vertebrates. Such significance as this ventricle has may be assumed to be in connection with the equilibrium of the cerebro-spinal fluid.

C. L. H.

Anatomy of the Cerebrum of Notoryctes.[2]

Although based on imperfect material and studied under adverse conditions, the notes upon the brain of this little-known marsupial will prove welcome. In respect to the brain at large the small size of the cerebrum and limited extent of pallium are correlated with the exposure of a relatively large part of the corpora quadrigemina and a very simple condition of the cerebellum.

The cerebrum presents an extreme simplicity of structure and while is has superficial resemblances to Talpa and Dasypus it is yet in

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[1] Ueber die terminale Partie des Rückenmarkes.

[2] G. Elliot-Smith. The Comparative Anatomy of the Cerebrum of Notoryctes typhlops. *Trans. Roy. Soc. Australia*, 1895.

morphological plan identical with the apparently dissimilar Macropus. The mesal olfactory fossa is absent but it does not appear whether this is correlated with any peculiarity of the Jacobson's organ.

The pyriform lobe takes an increasing share in the formation of the lateral part of the hemisphere as the extent of pallium decreases. The region reaches the height of its development early in ontogeny and phylogeny, hence its surface always remains smooth. Herrick and Bawden are criticised for confusing of the hippocampus when they evidently mean the pyriform but this criticism apparently rests on a misapprehension. The tuberculum olfactorium is of great size. Hill's usage in excluding this body (the post-rhinal lobe) from the rhinencephalon is characterized as "ridiculous"—an expression which must be accepted as applying to the critic's risibilities alone and which oversteps as a personal reflection the limits of professional courtesy. The author evidently meant "preposterous" or "inconsistent" but this must depend on the morphological extension involved in the term rhinencephalon.

Additional illustrations are given presumptively in favor of the view that the "commissura pallii anterior" is not a callosum, but incidentally illustrating the long-questioned fact that there are two dorsal commissures in marsupials, which, after all, has been that chiefly in the minds of the writer and others who have sought to enforce the distinction between the hippocampal and callosal portions of the dorsal commissure.

The reader may seek the original for a variety of details and generalizations.

The illustrations are far from successful. C. L. H.

Romanes on Weismannism.[1]

This new edition of the "Weismannism" is well printed and furnished with an excellent portrait of the author. It is one of the few really good cheap books which stand in so marked contrast with the tendencies of the time in book making. We have already noticed an earlier edition, but would again call attention to this discussion of the theories which Weismann has erected on the basis of his fundamental postulate of the non-inheritance of acquired, or somatic characters, as assuming a new importance in the light of the more recently published work of

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[1] An Examination of Weismannism. By GEORGE JOHN ROMANES. *Chicago, The Open Court Publishing Co.*, 1896, Price 35 cents.

the same author in which he has discussed the truth of this postulate.[1] The two books should be read together, if one would gain a true view of Mr. Romanes' views on these important questions. C. J. H.

Germinal Selection.[2]

The address delivered by Dr. Weismann before the International Congress of Zoologists at Leyden, 16 Sept., 1895, is here expanded and translated. The fundamental difficulty urged against Weismann and the other so-called neo-Darwinists by their critics is the impossibility of accounting for many of the adaptations as we find them on the basis of a theory of natural selection which recognizes only indefinite variability. The simultaneous occurrence of the variations necessary to produce, e. g., a case of mimicry in a butterfly, is hardly credible except on some hypothesis of definitely directed variability. The hypothesis of germinal selection assumes that when natural selection acting on accidental somatic variations in the manner usually described has resulted in a slight increase in the efficiency of the part in the given direction, then the determinants corresponding to that part in the germ-plasm of the next generation will be more vigorous than the determinants of other parts and in the struggle for food will outstrip them. Thus that part will in the adult be stronger than it was in the previous generation, and this result will be cumulative. So the germ is progressively modified in the direction set by utility.

Though very little has yet been published on this specific phase of the problem, the general question of definitely directed variation is one to which every thoughtful biologist must have given some attention. The success of this attempt to explain the mechanism of the process will rest on the value of Dr. Weismann's scheme of the hereditary machinery. And in estimating this we must recognize the purely symbolic nature of the conceptions used by the author of this scheme, a fact of which, as he points out, his critics have often failed to take account.

To one who, like the reviewer, is unwilling to admit the absolute non-transmissibility of somatic characters it is obvious that the argument for germinal selection cannot be accepted exactly as here outlined; yet the principle may be a true one and is not necessarily incompatible with an application of some form of the Lamarkian doctrine as well. C. J. H.

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[1] Darwin and After Darwin. II. Post-Darwinian Questions, Heredity and Utility. *Chicago, The Open Court Publishing Co.*, 1895.

[2] WEISMANN, AUGUST. On Germinal Selection. *Chicago, The Open Court Publishing Co.*, 1896. Price 25 cents.

The Psychology of Attention.

This is the third revised edition of the authorized translation published by the Open Court Co., Chicago. There is perhaps no writer who has done more to popularize the idea that a neurological foundation is essential to the full comprehension of the higher mental activities than Professor Ribot. Of the value of this standpoint we have no better proof than the stimulus which has been given to recent research by Professor Ribot's own works. Even those who cannot accept all of their conclusions are ready to acknowledge their indebtedness to them for many pregnant ideas.

We can summarize the present book no better than in the author's own words. "Attention depends on emotional states; emotional states are reducible to tendencies; tendencies are fundamentally movements (or arrested movements) and may be conscious or unconscious. Attention, both spontaneous and voluntary is, accordingly, from its origin on, bound up in motor conditions."

C. J. H.

Studies from the Yale Psychological Laboratory.

Volumes I and III of these studies are on our table. Volume II has already been noticed. The first volume is concerned mainly with investigations in reaction time. The most extensive article is the thesis of Dr. Bliss on "Reaction-time and Attention." Throughout this series of many hundreds of reactions especial attention was paid to the subjective state of the reagent. After having demonstrated that perfect darkness in the reacting room is in no way preferable to a uniform illumination, the reagent—in most cases Dr. Bliss himself—sat with pencil and paper at hand and at the close of each series of experiments annotated them. In many respects the most valuable part of the paper is the analysis of the reactions in the light of the data of introspection. This principle, which has been more recently recommended and practiced at the Paris laboratory, is one of great importance. The prevailing German tendency to reduce the reacting subject to a mere automaton, while in many experiments useful, can never give the whole truth.

Not the least valuable part of the paper by Dr. Bliss is the very full description of the apparatus and the details of the connections employed. Indeed this is an important feature of nearly all of the studies included in these three volumes. From the inauguration of the Yale laboratory the devising of new apparatus and laboratory conveniences has been given a prominence which puts all other workers under obligation, an obligation which the present writer gladly acknowledges, as he has found many of these contrivances very useful in his own laboratory.

The leading article in the third volume is by Dr. C. E. Seashore on "Measurements of Illusions and Hallucinations in Normal Life." This is a paper of vital importance to every laboratory psychologist, for the conclusions reached have an important application to some of the most fundamental methods of the experimental method. By an elaborate series of experiments, the details of which must be sought in the original, Dr. Seashore has shown the truly surprising ease and vividness with which it is possible to evoke illusions and hallucinations in every department of sense and that too in experienced psychologists and under the conditions of rigid control of the laboratory experiment. The hallucinations here described are evoked mainly in response to forced expectant attention and it is shown that this is one of the factors which must be guarded against in all experiments on liminal differences. Certain experiments on discrimination and many other classes of laboratory studies will receive cautionary hints from this paper.

The "Studies of Fatigue" by John H. Moore take up the effect of fatigue on binocular estimate of depth, the effect of fatigue on monocular estimate of depth, the effect of fatigue on the time of monocular accommodation, and the effect of fatigue on the maxium rate of voluntary movement. Several points of practical pedagogical interest are developed. For instance, several of these experiments on the estimation of depth by means of the muscles of accommodation and convergence emphasize the extreme danger to the eyes of carrying on for long periods of time such accommodation as must be employed in copying unfamiliar subjects from the blackboard to the paper or slate, as is so often done even in the lower grades of our schools. C. J. H.

The Embryology of the Medulla of the Rabbit.[1]

In this paper Dr. Dexter has followed the development of the medulla of the rabbit in order to make comparisons with that of man as worked out by His. He finds several differences, some of them quite unexpected. The tractus solitarius is buried more deeply in the medulla as development progresses by the migration, as the author supposes, of scattered ectodermal elements lying on the border of the medullary wall and "*Randschlier*," and not by the formation of a rhom-

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[1] FRANKLIN DEXTER, M.D. A Contribution to the Morphology of the Medulla Oblongata of the Rabbit. Privately printed from the Archiv für Anatomie und Physiologie. *Boston*, 1896.

boidal lip as in the human medulla. The rhomboidal lip as described by His was nowhere developed. The tractus solitarius is not regarded as wholly homologous with the oval bundle of the cord. The tractus solitarius is shown to receive fibers from the V, VII-VIII, IX and X ganglia very much as in the Amphibia.

C. J. H.

Uranism.[1]

This extensive work of over 350 pages is devoted to a thorough exposition of the subject of unisexuality in all of its aspects. It is a work of more limited scope than Krafft-Ebing's famous "Psychopathia" and is written from an entirely different standpoint. It resembles that work, however, in the vast wealth of its historical, statistical and critical data. It is not our purpose to attempt an abstract of the author's conclusions. With many of his positions our readers are already familiar. We need only add that we are in full accord and sympathy with his thesis that the misfortune of congenital sexual inversion is in no sense a justification for any form of sexual immorality. The subject is confessedly a confusing and perplexing one in all of its phases, but this point we think Mr. Raffalovich has quite satisfactorily established. And this is by no means incompatible with the further claim that the sexual invert ought not to be expected to conform in all respects to the mode of life of those who are normal in this respect. But if it should prove impossible for him to conform to this norm, it does not follow that he should not put the same restraint upon himself to which many another and perfectly normal person must often submit himself.

C. J. H.

Electricity in Electro-Therapeutics.[2]

This little book is, as the title indicates, a treatise on electricity, nor a treatise on electro-therapeutics. The authors have succeeded for the most part well in their attempt to so present the principles of electricity that any physician may comprehend them, even though he may have had no previous technical training. The book is to be commended as just what the practitioner needs to enable him to use intelligently the electrical apparatus with which his office is, or should be, supplied.

C. J. H.

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[1] Uranisme et Unisexualitè. Etude sur diffèrentes manifestations de l'instinct sexuale. By MARC ANDRE RAFFALOVICH. Bibliothèque de Criminologie. *Lyon*, 1896.

[2] Electricity in Electro-therapeutics. By EDWIN J. HOUSTON, Ph.D., and A. E. KENNELLEY, Sc. D. *New York, The W. J. Johnston Co.*, 1896. Price $1.00.