

magnificent instrument by Alvan Clark, and lastly, Mr. Sawyer, of Cambridgeport, undertakes to report on his interesting systematic observations of meteoric phenomena.

As "SCIENCE" is published weekly this information will be mailed to astronomers every Friday evening, and should important astronomical information reach us early in the week, we undertake to mail a special despatch, giving the information mentioned by Professor Swift. We think this programme will be a prompt compliance on our part, with the request made in Professor Swift's letter, and we trust will be acceptable to astronomers; we further ask the co-operation of all possessing, or in charge of, observatories to put themselves in communication with us and make suggestions, as it is our desire to make the most perfect arrangements, and to offer in "SCIENCE" a medium for universal intercourse for those engaged in astronomical studies.

In regard to other branches of science, equally important arrangements are being made and will be shortly announced.

CONTRIBUTIONS TO ENCEPHALIC ANATOMY. —THE OBJECTS AND METHODS OF A STUDY OF THE ICHTHYOPSIDEAN BRAIN.

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II.

Inasmuch as Huxley's class of the Ichthyopsida contains the lowest of the living vertebrate forms, it would appear one of the most important undertakings for the cerebral anatomist to determine the structural relations of the brain, spinal chord and principal nerves in that class. In fact, *a priori*, the student might conclude that the anatomy of a simple brain like that of a fish would represent a sort of rough and rudimentary sketch of the fundamental features of the higher mammalian brain, and that for this reason alone, its study would be essential to the human anatomist.

Nothing could be more erroneous!

Any one familiar with the visceral and osteological anatomy of the fish tribes will bear me out in the statement, that however convenient it may be to pigeon-hole the Amphibia, Elasmobranchi, Teliosts, Ganoids, Dipnoi and Marsipobranchi in one great class, on the strength of the formal common character, that they have no amnion at the embryonic period, and always have gills at some time of or throughout life,* that there are actually

more fundamental diversities between the different primary groups of this class than between at least one group of this class and the Sauropsida.

As it would be difficult to find an archetype of the vertebral skeleton in any ichthyopsidean, so it is a task requiring far more discrimination and careful study than is generally devoted to this subject to determine the cerebro-spinal archetype in any member of this group, aside from the protean amphibians. For there are greater differences between the architecture of a shark's and a pike's, a herring's and a sturgeon's, an electric eel's and a lamprey's, than between an amphibian and a mammalian brain. While the differences between the brain of a frog and of a man can almost all be referred to quantitative variations in the relative proportions of similar and homologous parts, the differences between the brains of the other animals named are of a qualitative character. It actually becomes a question whether a homology between the parts of an amphibian and of a shark's brain can be established.

Notwithstanding the difficulties enshrouding this subject, both writers on human and on comparative cerebral anatomy skim over the subject with a remarkable *nonchalance*. The latest compilation on the human brain* neglects any mention of the fact that the cerebral lobes of fishes are commonly solid, informs the student that there are symmetrical halves in these animals constituting a cerebellum, and repeats the statements of as old an author as Cuvier without the slightest reference to the recent controversy on the homology of the fish's brain, in which Gegenbaur, Fritch, Stieda and Macley have taken part.

The text book on Zoology used at most of our colleges, Packard's work, on passing through the ordeal of criticism at the hands of Wilder, is shorn of nearly every statement it makes regarding the fish's brain, since scarcely a reliable one is contained in the volume.

The question of the true homology of the fish's brain being still *sub judice*, the human cerebral anatomist can only lose time, and writers on the human brain only confuse their students by devoting attention to this problematical subject.

It is a legitimate field of study for the zootomist alone, and in its morphological respects the subject bids fair to prove rich in surprising and suggestive results, which, when once established on the basis of observation, may be utilized by the human anatomist and physiologist in generalization.

The questions to be determined will appear from the following; their answer is as yet a desideratum.

1st. A careful surface study of the brain of at least one representative of each great group should be made. Careful and enlarged representations of each such brain as projected in the five cardinal views, namely, the dorsal, ventral, lateral, anterior and posterior should be drawn, and the brains preserved for reference, in the manner to be detailed.

2d. A median section of each such brain should be made, and delineated, in order to expose the axis contours of the ventricular cavities.

* These are the only constant characters separating them from other groups, and it is even doubtful whether we are justified in denying the existence of the morphological representative of the amnion in all the amnia.

* "The Brain as an Organ of the Mind," by H. Charlton Bastian, 1880.

3d. A longitudinal section nearly parallel with the former, running from the anterior prolongation of the olfactory bulb through the middle of *each* cerebral and optic lobe, and striking the lateral convoluted mass of the medulla oblongata, could be made from the same brain, as a supplement to the elucidation of the internal contours.

4th. One horizontal dissection exposing the ventricular floors, from above, and another exposing the ventricular roofs from below, will still further clear up these relations.

5th. A series of transverse sections, taken perpendicularly to the peduncular axis, will be essential to a comprehension of the relations of the ventricles and deeper parts for each altitude. The sections should be taken at distances of from one to three millimetres apart, according to the size of the brain, then preserved in separate bottles and labeled in numerical order.

All these preparations should be made from brains hardened in absolute alcohol, and the dissections should be made after the brain has been kept thus for one month, if the working season is in summer, and one or two weeks or even a few days, if the season is winter.

My plan, when engaged in this and similar work, has been to expose the cranial cavity by cutting away the surrounding parts with a strong knife until the brain level is reached. This requires very little practice. Then the lateral walls are broken away with a forceps, or cut away the same knife, and the student may then clear up the tracks of the cranial nerves for a short distance. The brain is not to be removed from the skull base, but left in contact with it, a smooth round head of a needle may be employed to bread up the arachnoid attachments there, and facilitate the penetration of alcohol to the basilar parts, but this is all that should be done. The brain must be immersed in alcohol, with the base of the skull in connection therewith, at least by means of the emerging nerve roots, else the topography may become disturbed.

The membranes (excepting the dura of the convexity) should not be touched, for it is desirable to trace their connections with plexiform structures penetrating the fissures and cavities of the encephalon, as these may be of service in explaining certain homologies.

Alcohol is selected as the preserving fluid for the reason that it does not render the specimens too brittle for coarse dissection, which the chromic salts do, nor distorts the contours as does glycerine.

The transverse sections can be made in a microtome, moving the piston the distance of the thickness of the required section, before each section is cut. Previous to each cutting, the imbedding matrix should be removed to a little below the level of the section. All other sections can be made without a microtome, it being well, however, to fix the brain in a wax or a paraffine layer, poured on a glass plate. Adherent particles of the material thus used can be subsequently removed with turpentine, when the specimen is prepared for permanent preservation. It is needless to add that all sections and dissections can be done a hundredfold better under the surface of a fluid like alcohol or

water, than by simply wetting the knife with these fluids, as text-books direct.

All the work so far mentioned is only preparatory however. It is merely destined to furnish on the one hand a topographical guide to the more important work which is to follow, on the other to supplement the ascertained relations of ganglionic masses and fascicular tracts by a plastic conception of the encephalic segments which contain them. The work which is to follow is far more tedious, but also far more important; its methods are those employed in studying the microscopic anatomy of embryos.

For the purposes of microscopic anatomy the brains of smaller species are as preferable, as those of the larger species are desirable for the coarse anatomy. The brain of a sturgeon twelve inches long, will show all the microscopical details as well, and be easier of manipulation than that of one twelve feet long. The latter's had best be devoted to naked eye study.

If the weather is cold, the animal perfectly fresh, and the specimen can be kept in a temperature near the freezing point (it should never reach or drop below the latter,) the brain can be immediately transferred to a solution of chromic acid of a light sherry color. In my experience this tint, tested in a two ounce graduate, is a far more reliable gauge than any weighing by so many grains to so many ounces, that is ordinarily recommended. After staying a week in this solution, it is transferred to one of bichromate of potash, having the same color. Here it remains, care being taken to have always at least one hundred times as much fluid volume as specimen volume, until the desired degree of hardness is attained. The latter is hard to describe in words, but an adequate conception can be best conveyed by saying that the specimen should be unyielding to pressure, and yet not altogether inelastic. The membranes will now separate readily, and the specimen, first washed in water, is transferred to a neutral (long stood, and repeatedly filtered and mouldless) carmine solution, so concentrated as to appear black in a depth of six inches. Here the specimen is left for from one to three weeks, according to the size of the brain. Then it is again washed, put in water containing two per cent. of glacial acetic acid for twenty-four hours, washed again, transferred to proof spirit for a day, then finally to absolute alcohol, until such time as the observer is ready to make his sections.

When this time arrives (and it is best not to defer it over a month) the brain stained and hardened as it is, is transferred to clove oil, which penetrates and drives out the alcohol in a few days. The translucency of the specimen is a sign that this has been accomplished. It is then taken off, the superfluous clove oil drained from the surface, and imbedded in a microtome with paraffine. The superfluous matrix being removed with each section, the cutting is done with turpentine, and each section, stained and transparent, can be transferred to its appropriate slide and mounted, so that the order in which each section belongs is preserved. This is an important advantage.

If the weather is warm, the brain should be sub-

mitted to absolute alcohol for a day before entire removal from the skull, then put in a mixture of methyl-alcohol and bichromate of potash, of a muddy beer color (thirty grains of the salt to the ounce of alcohol) for a week, and subsequently, for a variable time according as the specimen will harden, to simple Müller's fluid. The staining, cutting and mounting can be done exactly as in the former case.

Specimens prepared by the first method of hardening will furnish better results for the medulla, those hardened with the second will yield more complete specimens of the higher ganglia. It is a well known fact that fluids that will harden the medulla oblongata well will sometimes fail to render the cerebrum and mesencephalon fit for cutting.

Of course the most important series of sections will be one taken transversely to the peduncular axis. This should be made first, therefore, and studied in conjunction with the delineations made from the coarse specimens. Now the student having familiarized himself with the precise topography and extent of every ganglion, cortical expanse and fibre mass, is ready to proceed to more complicated inquiries, that is to study the *relations* of fibre masses. How he may proceed where a fasciculus does not run in a straight plane, I have indicated in a previous contribution to this journal.*

It is needless to say that in addition to these methods, which may be called systemic ones, inasmuch as they are calculated to reveal homologies and relations, that all other methods of hardening and staining may be used to study the finer and finest histology. They are of less importance, however, both to the zootomist and neurologist, than is generally supposed.

Now a word as to the objects of such an inquiry, for unless the investigator has a definite point in view, and a provisional notion of the subject he intends to develop, his work will be barren of result, save he stumble on some revelation accidentally.

a. The close relation between the cerebral lobes and the olfactory lobes of fishes may, if studied in all the groups, particularly the lampreys, lead to the establishment of a homology with the so-called cerebral lobes of the higher invertebrates.

b. The fact, which we have every reason to suspect to be a fact, that the cerebral lobes of fishes are the true homologues of the cerebral hemispheres of the mammalia, sauropsida and amphibia, requires to be definitely established. Prof. Burt G. Wilder questions this homology, on the ground that the cerebral lobes of bony fishes are solid, and contain no ventricles. That so acute an observer, one to whom we owe so much in the line of correction of gross errors which have found their way into standard text books, could lean his objection on such a doubtful basis, shows how catholic must become the principles, if I may so term them, of cerebral anatomy. The embryological development of the fish's brain presents features which no other vertebrate brain exhibits in the course of de-

velopment, namely, the entire central nervous axis is apparently solid. In truth it is hollow, but the cavity is a mere slit, the walls of which are in contact, and when the cerebral lobes become solid they do so by the fusion of these walls and the obliteration of the slit. The ventricle is therefore not an essential feature of the cerebral hemisphere, and as if to prove this fact beyond a doubt, we find that among animals as nearly related as sharks, some have true ventricles in these lobes communicating with the third ventricle, while others have them as solid as the bony fish.

c. The derivation of the olfactory bulb, a structure often and unwarrantably confounded with the olfactory lobe, can be best studied in fishes.

d. The same applies to the cerebral epiphysis and hypophysis, still known by the improper titles of pineal and pituitary glands.

e. The relations of the peculiar *lobi inferiores* to the optic nerve, and the asserted homology of the *corpora candicantea* require confirmation.

f. The question of the homology of the cerebellum and optic lobes, which is in a very unsettled state to-day, is yet unanswered. Wilder, in his paper on the brain of the *Chimæra*, has exposed the fallacious interpretations which most authors have made in this regard. His essay will prove valuable to those engaged in this inquiry. Possibly the discovery by myself of the entire distinctness of the post-optic and the hitherto unknown inter-optic lobes in reptiles, from the optic lobes proper, may assist in unraveling the true relations.

g. Since among fishes we find many examples of remarkable development of the periphery, I need but instance the rostrum of *Spatularia*, the great lateral expansions of the skate, the asymmetry of the Flounder, the rudimentary eyes of *Amblyopsis*, the marsupium of the Hippocampus, and the immense jaw of the Angler, an inquiry dealing with the relations of nerve centres to the projected peripheries may be expected to furnish many suggestive facts bearing on the projection doctrine.

All through these lines it will be seen that as in every other branch of morphology a study of embryonic development is an essential to a proper knowledge of the fish's brain. A brief consideration of the methods to be employed in this field of the study will not be out of place.

Spawn can be obtained living from our fish hatching depots, whose superintendents will be found very obliging towards those requiring material for scientific study. The different stages of development, extending to beyond the period when the young fry escapes, can be obtained by permitting the ova to develop under the eye of the observer in a hatching trough.

The ova of bony fishes are dropped into a solution of chromic acid, or Müller's fluid; better, a few specimens are taken out each day and dropped each into differently strong solutions of the former and into the latter. I know of no standard strength that will yield uniform results, and have while working in this field in Vienna lost thousands of ova by following the routine directions.

From the chromic acid and Müller's solutions the spawn is transferred to alcohol in from two to

* Part I. of this series, *Journal of Nervous and Mental Disease*, 1887, p. 668.

twelve days, the younger the germ the less time should it be exposed to chromic acid. After having been in alcohol a week it is transferred to a sherry wine colored solution of bichromate of potash for a period sufficient to harden it.

With a cataract needle the investigator will then cut a trench around the embryo, cutting through the vitelline membrane, which fixes the embryo to the vitellus, and then lift it away and remove it from the latter, which, brittle and crumbly, cannot be cut. The staining in a solution of carmine, as described for adult brains in this paper, will require from one to four days, according to the size of the embryo. Of each stage three series of sections are necessary, one transverse, one horizontal, and a third, the most important, sagittal, that is parallel to the median plane.

All these minutiae, however wearisome they will prove, are necessary, and he who has thus with his scalpel, reagents and razor, constructed an open volume of natural specimens, will find himself richly rewarded by the richness in detail, the manifold character of the morphologies, and the suggestive character of the relations exposed.

The material for such a study can be obtained in a fresh state from no one locality. The student residing in New York will have to take a vacation trip to the Mississippi; he living in Chicago a corresponding trip to the Atlantic coast.

In the West he will find the great lake catfish, the lake sturgeon, the *Amia calva*, the gar-pike, and the remarkable spatularia, the brains of all of which should be studied. Possibly he may obtain the fresh water lamprey (*Hylomyzon*), but one brain which he should not neglect is that of the blind fish of the Kentucky caves, whose examination is destined to clear up somewhat the true relations of the *lobi inferiores* and the optic lobes. On the Atlantic coast all the bony fish, obtainable in the fresh waters of the West, besides a rich variety of salt water forms, also the lamprey, the shark and ray are obtainable. A trip to the Bermudas or the Florida coast, occupying about two weeks, will increase the student's *repertoire* with a host of tropical and sub-tropical genera.

WEIGHT, SPECIFIC GRAVITY, RATES OF ABSORPTION, AND CAPABILITIES OF STANDING HEAT OF VARIOUS BUILDING STONES.

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Having during the past year instituted, and carried out, a series of experiments to ascertain, as nearly as possible, the capabilities of the various materials used in the construction of so called fire proof buildings, to stand heat, I submit, in tabulated form, the result of such experiments, hoping they may be of use to the architects, quarrymen and Insurance companies of our country, and also of some interest to those interested in science.

In connection with the capabilities of the various building stones to stand fire and water, I have taken their specific gravity, and weight per cubic foot, so that the identity of the various stones could at any time be com-

pared, and if in the working of a quarry there was a change in gravity, or weight, that it could be easily detected, and thus all who choose could know whether the tests given would apply or not.

I have procured sample specimens of the most important building stones in the United States, and Canada, and, after dressing them into as regular form as possible, three by four inches, and two inches in thickness, I have taken their ratio of absorption, which ratio I have expressed in units of weight, according to the amount of water taken up. If 450 units of stone absorbed one unit of water, I have expressed it thus: 1 + 450, meaning that the stone weighed 450 units when immersed, and 451 when taken from the water.

To accelerate the process of absorption I have placed the specimens in water under the exhausted receiver of an air pump. I find that in this way as much water is absorbed in a few minutes as in days of soaking. When specimens were removed from the water, I have, before weighing, dried their outsides with blotting paper. In relation to the specific gravity, I have not followed "Gilmore's" rule in full. He weighed the specimens in air, immersed them in water, and allowed them to remain until bubbling had ceased and then weighed them in water, after which he took them from the water, dried them outside with bibulous paper, and weighed them again in air. From this last weight he subtracted the weight in water, dividing the dry weight by the difference.

This gave a specific gravity subject to two sources of error. I have followed the more frequent custom of weighing the dry stone, using pieces of two or three pounds in weight, and then immersing them in water. After the usual saturation I have taken their weight in water, subtracting it from the dry weight in air, and then dividing the dry weight by the difference. This gives the specific gravity of the rock itself, as usually found, which is what we desire, and I believe as it would generally be in buildings constructed of the given material. The specimens were previously dried by long exposure to a temperature not exceeding 200° Fah. To verify this I have taken specimens from the quarries direct, and after weighing, have brushed them over with paraffine dissolved in naphtha, weighing them again so as to ascertain the exact amount of paraffine, which made no visible change in the stone, other than to keep out water. I have then weighed in the usual way, and thus obtained the exact specific gravity of the stone as in the quarry, and I find my method used, as stated, to give the best results, and so have adopted it.

After this I have placed them in a charcoal furnace, the heat of which was shown by a standard pyrometer. In many instances I have placed them side by side with dry specimens, but have been unable to note any marked difference in the action of heat, beyond this, that the dry specimens became sooner heated. I have, however, no doubt that the capacity of a stone to absorb water is against its durability, even in warm climates, and vastly more so in the changeable and wintry climate of New England. It is here often frozen before any considerable part of the moisture from Autumn rains can be evaporated.

When the specimens were heated to 600° Fah., I have immersed them in water, also immersing others, or the same, if uninjured, at 800° and 900°, that is if they are not spoiled at less temperatures. I find that all of these samples of building stones have stood heat without damage up to 500°. At 600° a few are injured; but the injury in many cases commences at or near that point. When cooled without immersion they appear to the eye