Dr. Lambert answered that the corpus callosum connection had been tried in a good many cases, children as well as adults, and, so far as they could tell, permanent drainage had been established.

Dr. Sachs said the procedures were very interesting and the results in a large number of cases should be watched for. He would like to ask if the other procedure was an easy one and how long could the connection be kept open.

Dr. Lambert said he did not know exactly how long, but at least several months.

Dr. Brush said he had seen two such cases, where permanent drainage had been established through the corpus callosum. A child had been kept alive for nine months, but beyond that there was no noticeable improvement. The death finally occurred from marasmus. The question was, was it really worth while keeping a child alive in a case where the brain was badly malformed from birth and the child would be defective? Simply to perpetuate malformed beings could be hardly worth the trouble.

Dr. Leszynsky said he was not familiar with the method of drainage from the subarachnoid space or into the peritoneum. He had had some experience with the corpus callosum method. The doctor had said his procedure was a simple affair. He would like to ask if it was difficult to pass the tube into the ventricle. Was it strong enough to go through the callosum, or had it to be passed afterwards? Sometimes when the callosum had been punctured the opening remained patent for many months.

Dr. Lambert said the tubes were passed on the stiff canula. They fitted on the end of it. The canula was withdrawn and the tubes were left in situ.

SOME APPLICATIONS OF THE NEURO-BIOLOGICAL METHOD OF INVESTIGATION TO THE STUDY OF CONSCIOUSNESS

By Stewart Paton, M.D. (by invitation)

Dr. Paton gave this paper to the Society rather as a point of view than as a statement. A philosopher had said that only one thing was more misleading than statistics and that was a fact. This principle was apt to hold where isolated facts were concerned. The problem of consciousness should be approached from the broad biological standpoint and it would then be found that some of the difficulties of this investigation would vanish. Reactions of organisms should be studied as units. Even the reflex could not be understood by itself, but only in connection with all the other biological reactions. Reactivity depended upon factors both inside and outside of the nervous system. Any problem of reactivity looked at only from the human standpoint was unnecessarily complicated. Excellent material for the study of the simplest reactions of the embryo was found in the shark, lizard, guinea-pig, rat and chick. In the case of the shark embryo it was possible to study the primitive functions in relation to the structural changes without disturbing the natural environment. When approaching the great problem of correlation of structure and function from the comparative point of view, the great gulf which seemed to exist between man and the lower animals did not seem to be broad or deep enough to discourage the investigator in his efforts. As a matter of fact the functions of the lower animals and those of man did not seem to show any greater contrast than existed between the lower and higher functions of the human brain. Until quite recently the number of investigators in this important field was a limited one. Wintrebert, a French scientist, had attempted to bring the simple reactions of the organism into some sort of correlation with the structural conditions. The first movements that took place in the embryo were those of the heart and it was not difficult to

think of the causes which gave rise to the cardiac pulsations as being quite similar to the changes taking place in chemical reactions. The first movements of the body were not influenced by incident stimuli; in other words, the organism was not responsive to external excitation. At the moment incident stimuli became effective the reflex arc, marked by bundles of neurofibrils, but without any signs of medullation, was completely differentiated. A chick embryo at 120 hours of incubation, placed in Ringer's solution, responded readily to stimulation by means of a platinum electrode connected with a single dry cell. At this period when the first reactions to incident stimuli began, a number of important organs had been differentiated and had received their nerve supply. Large bundles of neurofibrils might be detected running from the vagus to the thyroid; and other bundles were noted in connection with the adrenals. The sympathetic nervous system had reached an advanced stage in the development. In connection with the conduction of currents by these primitive nerve tracts prior to the appearance of medullary sheaths it was interesting to note that there was a possibility of the nervous impulse following the law in the invertebrates of running in both directions. There were reasons for asking whether the specificity of the posterior and anterior roots might not begin with medullation. The question was an interesting one as to whether medullation determined the direction of the nerve current. The correlation of structure and function in the case of these primitive responses had a very important bearing on the problem of consciousness. The higher forces of consciousness were undoubtedly closely related to the functional activity of the higher brain centers, namely, those contained in the cerebral cortex. From what was already known about the physiology of the brain it was quite clear that we could not understand the functions of the higher centers without considering these in their relation to the mechanism of the great basal ganglia. The functions of the cortex were long misunderstood and only recently had it been appreciated that this structure controlled, but did not initiate legislation. In the primitive reactions of the embryo there existed an excellent opportunity for observing the development, not only of the basal ganglia, but also changes taking place in the cortex could be noted, when it first began to be a dominant factor in determining the character of the mechanism. Professor H. H. Lane had shown that the first reactions to olfactory stimuli took place at a time when the terminations of the nerves in the olfactory bulb were connected directly with the basal ganglia, medulla and cord without any relations to the cortex. It was an extremely interesting problem to try to analyze the different elements entering into the reaction when the higher centers had assumed control. Other centers were capable of being studied in a similar manner. One important fact in connection with these primitive reactions deserved special consideration, and that was at the moment when the embryo first reacted to incident stimuli in the shape of electrical stimulation or needle pricks, although the thyroid and adrenals were included in the closed circuit, the sex glands had neither received their nerve supply nor were they sufficiently differentiated to be taken into account. This might indicate that the thyroid and adrenals became factors of dominant importance in neurobiologic reactions at a period which preceded that of the sex glands. (Dr. Paton then showed lantern slides, illustrating the development of neurofibrils in the embryo, showing the early development of the sympathetic, thyroid, spinal ganglia as well as the thyroid and adrenals.)

Dr. Bernard Sachs said that Dr. Paton had given them more material to digest than to discuss. He had great hesitation in making statements on the subject. He felt that this presentation was very much in line with the work of Edinger in comparative embryology. Dr. Sachs believed that the correlation of structure and function could be best attempted on this line. The

problem which engaged Edinger was the first beginning of consciousness as exhibited in the lower animals. In an exhibition of some mechanical toys he had shown that what were usually considered conscious movements, such as avoidance of an obstacle, were really to be explained by laws of physical forces. The whole subject was extremely complex, and Dr. Sachs could not say how the psychologist was coming out in the solution of many of the problems offered by this study. In most textbooks on psychology there was a long first chapter devoted to the anatomy of the brain, and this was carefully avoided in the rest of the book. The fact pointed out by Dr. Paton of the very early innervation of the thyroid and adrenals was of great interest. Presumably these organs had most to do with the early physical development of the chief organs of the body, and they needed their nerve supply very much earlier than the other parts. In regard to the point of localization, Dr. Sachs was glad to hear that Dr. Paton was returning to the standpoint of his old master, Golz, who was always an antagonist of the view of strict cerebral localization, and who always claimed that it was an absurdity to say that the brain was divided into small sections with special function. He claimed that function was the result of coöperation of many different parts of the brain. The paper to-night gave neurologists a great deal of inspiration. Dr. Sachs hoped that Dr. Paton would elaborate this early beginning. They would be very glad if this suggestion led to a further study of the question of consciousness.

Dr. E. Fisher said that Dr. Paton had stated the materialistic side of mental action. It could be said that he had given a body blow to psychoanalysis. In regard to neurofibrils and medullated fibers, Dr. Paton was speaking of a very primitive form of reaction. In specialized reaction there must be some form of insulation. In regard to distinct areas of localization, Dr. Fisher thought one must have these. He could agree with the generalization of control, but in pathology certain areas were found destroyed by disease, resulting in impaired function. There were higher centers, but one did not know exactly what that meant in mental action. At the same time one could not do without definite areas of the brain that responded to the spoken or written idea. Dr. Fisher thought the meeting owed a great deal to Dr. Paton for awakening interest in new ideas of mental action.

Dr. Walter Timme said there were two questions on the sympathetic development of the early embryo which were interesting. The reason for the early development of a comparatively large mass of sympathetic fibers might be answered as follows: The sympathetic nervous system did not alone control function, but it did also control the actual cell growth. It regulated both the number and character of the cells. In the early period of life cells increased to the most rapid extent, so that it would follow that the fibers which controlled normal development would have to be increased in proportion. In experiments on animals results had been shown, that if one cut the sympathetic fibers and excluded them from performing their function, the organism would change macroscopically. The actual increase or decrease of cells would depend on the nature of the experiment. With diminished vagus control over the glandular region of the stomach and intestine there was actual increase in the number of cells. With diminished sympathetic fibers there was actual diminution of the cells. As to the antidromic passage of the current in non-medullated fibrils, that occurred in the higher animals. All of the post-ganglionic fibrils were non-medullated, in distinction to those which passed from the spinal cord to the ganglion, which were medullated. In post-ganglionic axon reflexes the current passed both ways. Actual stimulation at the upper portion of the gut caused the current to pass through the non-medullated fibers in an antidromic direction, and so cause the following section of gut to adapt itself to the oncoming bolus. The meeting owed Dr.

Paton sincere thanks for his clarity of presentation of a new viewpoint in the study of consciousness.

Dr. Joseph Byrne said that it had been well known for a long time that the basal ganglia had functions similar to those referred to by Dr. Paton. It was a commonplace in the physiological laboratory to find that after removal of the cerebral cortex a frog could avoid obstacles. Such a frog, however, was utterly incapable of conceptualizing, and would starve to death though food lay in front of it. Sherrington had recently shown that the cerebral cortex was not necessary for the elicitations of auditory reactions. Again, clinico-pathological study had shown that in lesions isolating the thalamus from the cortex certain affective elements of sensation were preserved, viz., those evoked chiefly by protopathic stimulation. Dr. Byrne did not feel that Dr. Paton, in so far as he had gone, really touched upon the phenomena of consciousness. The electrical and olfactory reactions mentioned did not rise to the dignity of consciousness as the term is understood.

Dr. S. P. Goodhart said that Dr. Paton adroitly avoided going deeply into the subject of higher forms of consciousness, though stimulating important considerations from the doctor's most instructive demonstrations. The theme of correlation of nerve reaction and function had been given a clear aspect and the speaker's experiments and deductions, simple in themselves, were the more valuable as bearing out Dr. Paton's contention that consciousness, as conceived in man, would finally be most clearly understood by first observing the simplest processes of nerve structure in its relation to the development of function in the lower forms. If consciousness in the humble species, the frog, for example, was, as Dr. Paton's experiments may be regarded, but reflex, then in man too could not one regard conscious activities, even judgment, volition, emotional reaction, as but highly complex reactions, automatic or reflex; such reflex responses as the result of past experience within the individual, acquired and inherited formulæ, physically formulated to expression. Then, too, as Dr. Paton had set out to show, the basal ganglia, perhaps, had not lost their original dignity. Thus, the simple process of consciousness conceived as such in the frog, apparently a simple reflex, might be the fundamental physical principle upon which one based the most complex mechanism of consciousness in the higher animals.

Dr. L. Casamajor said that he had understood Dr. Paton to make the point that the problem was best approached by beginning with simple things and working upward; thus anatomical structures were brought into relation with function, and consciousness studied from the point of view of the different elements which go to form it rather than as a single entity. The point Dr. Paton had made that no reflex defensive reactions were possible in the embryo till both parts of the reflex arc had established their connection with the periphery, was an important one, as establishing the fact that proper nervous connections were necessary for the animal's defensive reactions. Dr. Byrne's remarks concerning the inability of the de-cerebrated frog to seek out food, although he could still avoid obstacles, seemed rather far from the point. It did not prove the dependence of consciousness upon the cortex. The cerbrum in the frog was merely an olfactory receiving station and when it was removed the animal lost his olfactory memories upon which he was obliged to rely for his choice of food. There were certainly elements of consciousness in other nervous tissue besides the cerebral cortex. The spinal cord held something of consciousness in its reflex active capacity. Likewise there were elements of consciousness in the sensory nuclei of the medulla and surely in the thalamus. The simple reflex act itself implied something of memory in its capacity for repetition. This was the memory of sensory impulse, and it was upon sensory memories that all consciousness was based.

Dr. Stewart Paton, in closing the discussion, said that he did not mean his remarks to apply to localization proven by clinical experience, but to some of the absurd theories that were advanced from time to time. As regards consciousness, he had endeavored to make it plain that he had suggested a point of view, rather than given information. He wanted to get as many people as possible to approach the subject from the simple to the complex. If he had approached it from the higher standpoint there would be very little chance of dealing with the subject in one evening. There was no doubt that the basal ganglia had a tremendous influence on the higher centers. Reflexes moved higher and finally reached the cortex.

Dr. Leszynsky said he knew he was voicing the sentiment of the meeting when he said that they were very much indebted to Dr. Paton for this valuable paper.