A LECTURE ON PHYSIOLOGICAL DISCOVERY.

Delivered at the Royal Institution of Great Britain.

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LECTURE VIII.*—THE NERVOUS SYSTEM: NOTIONS OF NERVOUS ACTION GENERALLY.

ANATOMISTS were aware, from the earliest times, of the general appearance and position of the central nervous masses—brain, spinal cord, and ganglia—and of the nerves. For many years, however, the latter were confounded with ligaments and tendons. Galen first probably recognised the true nerves, and he satisfied himself by experiment that they were concerned in motion and in sensation. He upset the old theory of Aristotle that the brain was simply the organ in which the blood was cooled, the old notion being that the hot spirits carried from the heart to the brain with the blood were there cooled, and condensed into water, and that then this water was returned to the heart in the blood. Galen, however, imagined that the air passed from the nostrils through the ethmoid bone into the lateral ventricles. There it mixed with the vital spirit, brought to these ventricles through the arteries from the heart. Thus the animal spirits were generated, and were transmitted from the brain to the body by the nerves, thus causing sensation and motion. He also supposed that there was a kind of diastole and systole of the brain concerned in this function, and that, in addition, the ventricles were receptacles for effete matter, ultimately thrown into the nose, or, by the pituitary gland, into the palate. These notions were held for many centuries, and were generally taught by the Italian school of anatomists. Caspar Bauhinus (1559-1624), Professor of Botany at Basle, was amongst the first to assert that animal spirits were not generated in the ventricles, but in the brain itself. He was supported in this view by Caspar Hoffmann (1660-1743), a cotemporary of Stahl, and along with him, one of the Professors of Medicine at Halle. Stahl's views were entirely metaphysical. All bodily actions were directed by the conscious or unconscious interference of the soul, and it was therefore useless to pay any attention to anatomical investigation and to experiment. Hoffmann was less speculative, and did good service by insisting that all the nerves of the body arose either from the spinal cord or from the brain, and that the ventricles were not continuous with the nerves, but with the cavities of the body. Up to this time it was held that the nerves were tubular, conveying "animal spirits" from the brain to the body. Galen's notions received their final overthrow when Conrad Victor Schneider, Professor at Wittenberg, about 1641, proved by anatomical examination that matters could not escape from the ventricles into the nose in the way alleged.

The animal spirits, being thus dislodged from the ventricles, were now supposed to be secreted from the blood of the cortical substance of the brain—a notion originating with Malpighi (1628-1694). In England, Thomas Willis (1622-1675) made important investigations into the anatomy of the nervous system. Stimulated by the revival of interest in anatomy and physiology caused by the discovery of the circulation of the blood, he made numerous dissections, and figured and described the human and comparative anatomy of the brain and nerves. Whilst there is much fanciful and metaphysical matter in his writings, Willis occupies an honourable place in the history of nervous physiology, were it for nothing else than for insisting on the production of "animal spirits" (or, as we now understand the term, nerve-force) by the cerebrum and cerebellum.

The lecturer then briefly alluded to some of the old theories regarding the nature of nerve-force, and he pointed out that it had been a favourite speculation that mental faculties were located in definite portions of the encephalon. It was not, probably, until about the middle of the seventeenth century that nervous energy, call it by any term you will, was supposed to be due to the action of a kind of matter (whether it be matter in the ordinary state, or

matter in the hypothetical condition of "ether") formed in the brain, and transmitted to various parts of the body. The brilliant discoveries of Newton (1642-1727) had an influence on theories of nervous action; and in the *Principia* he states his opinion that all sensations and movements were excited by the vibrations of a "very subtle spirit," propagated through the solid "capillamenta" of the nerves from the organs of sense to the brain, and from the brain to the muscles. This was the foundation of the well-known vibration-theory of David Hartley (1705-1757). He held that sensation was the result of a vibration of the minute particles of the medullary substance of the nerves, and he called into action the hypothetical ether of Newton. This notion of another medium than the matter of the nerves has frequently arisen, as when it was supposed that electrical and nervous conduction were the same in kind. The Cartesian notion of a fluid running in the nerves was not abandoned even by Haller, as we find that, in the fourth volume of his *Elementa Physiologie*, published in 1762, he discusses the question as to whether the nervous fluid be albuminous, acid, spirituous, sulphureous, æriform, or etherial. Here he first uses the term "vis nervosa," as designating a kind of action which he found it impossible to explain. It is the correlative of the "vis insita" of contractile tissue, a recognition of which we also owe to him.

The next important thinker on this subject was John Augustus Unzer (1727-1799). The special merit of his work is that he laid the foundation of most modern views held as to the intimate connection between mental and physiological phenomena, thus being really the founder of medical psychology. As regards the action of nerves, he specially pointed out that some change is caused at the excited point which is carried along the nerve, and that artificial stimulation of a nerve produces, in the organ to which the nerve passes, precisely the same changes as would have happened had the nerve acted normally in the body. He also foreshadowed the notion of reflex action, although in somewhat vague terms. After him came George Prochaska (1749-1820), who worked out in much greater detail the views of Unzer, and especially had clearer notions of the mechanism of reflex acts. In the lecturer's opinion, however, the special merit of Prochaska's writings is, that he gave precision to physiological notions regarding the action of the "vis nervosa." He showed that a stimulus is necessary to arouse its action; that this stimulus may be either from the body or from the mind; that whilst the effects of stimuli are not always the same, this may depend upon the state of the "vis nervosa" at the time; that the "vis" may be increased or diminished; that it may exist in the nerves independently of the brain, and that individuals may exhibit a peculiar condition of the "vis nervosa" or an idiosyncrasy. These statements were published in 1784.

It might be expected that the brilliant discoveries of Galvani and Volta regarding animal electricity and electricity in general, occurring between 1786 and the end of the century, would affect opinion as to nervous action, both on account of the remarkable similarity between the electric current and the nervous current, and because the nervous action could be so readily excited by electrical stimulation. Probably the first to put forward this opinion was Valli, in 1792, and it received the countenance of Dr. Thomas Young and Dr. Wilson Philip. The action of electricity on the nerves was also studied about the same period by Lehot and Bellingeri, and thus was laid the foundation of one of the most elaborate departments of physiological work, namely electro-physiology. Many years elapsed before it was clearly shown that the conduction of electricity along a wire, and the transmission of the nervous force, whatever it may be, along a nerve, are phenomena of entirely different character.

The lecturer then described at considerable length the well-known observations and experiments of Charles Bell, fully published in 1824, but indicated in a private pamphlet published in 1811. He showed how Bell had, by direct experiment, determined the functions of the anterior roots of the spinal nerves, and the functions also of a portion of the fifth cranial nerve and of the seventh cranial nerve. These fundamental experiments led to the recognition of special systems of nerves connected with various functions, such as those of respiration, circulation, and secretion.

The next great step was taken by Johannes Müller (1801-1858), when he showed that a stimulus excites in all the organs of sense different sensations in each organ, namely, the sensation peculiar to it. Thus, in whatever way a nerve of special sense may be stimulated, the effect is always the same. For example, mechanical, electrical, or luminous impressions on the retina always produce the same effect, namely, a sensation of light or of colour. In like manner, electricity applied to the auditory nerve causes a sensation of sound.

* Lectures viii, ix, and x (the last of the course) will be devoted to the nervous system. Dr. McKendrick has found it convenient to depart somewhat from the order in the Syllabus.

In the language of Müller, therefore, "the sensation of light in the eye thus produced is not a development of the matter of light, but is merely the reaction of the optic nerve, which is susceptible of the sensations of light and colours only, not of pain. It is a particular state of the optic nerve, just as pleasant and painful sensations are particular states of the nerves of common sensation." This important statement has been called the law of "specific nervous energy," and has led to very important physiological results. When it was found that no histological distinction existed among the nerves, and that the only anatomical difference observable was their mode of termination in special organs, it was suggested that this invariable result, observed by Müller, does not depend on differences between the nerves of the senses, but on the kind of apparatus in which they end. Thus, nervous filaments having the same appearance may cause very different physiological results when excited, and the result will depend on the nature of the apparatus in which the filaments terminate. If they end in muscle, the effect will be contraction; if in a gland, excretion; if in blood-vessels, increase or diminution of their calibre; if in an electrical organ, electrical discharges; if in certain ganglionic cells, a reflex act; and if in the cerebrum, sensation and other mental states consequent thereon. This law has been a guide in all recent physiological investigation. It is assumed that the nerves themselves are similar, and that the results of division, pressure, or irritation, depend on the apparatus in which the nerve ends.

ABSTRACT OF LECTURES

ON THE

METAMORPHOSIS OF SUCTORIAL FISHES AND BATRACHIA.

Delivered at the Royal College of Surgeons of England.

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LECTURE VI.—ON THE EMBRYOLOGY OF THE BATRACHIA.

THE amphibia mostly lay their eggs on the water. These are small, almost spherical bodies, part of the surface of which is often black from a layer of pigment, while the rest is unpigmented. Each ovum is surrounded by a vitelline membrane, and receives, in its passage down the oviduct, a gelatinous investment. In the Batrachia, the eggs are fertilised as they leave the oviduct, and are laid in masses or strings. In the genus *Pipa*, however, the eggs are placed on the back of the female by the male, as soon as they are laid, and a pocket of skin becomes developed round each egg. The larvæ are hatched and undergo their metamorphosis in these pockets. The female during this period lives in the water. The female of one of the tree-frogs of Ceylon carries its eggs attached to the abdomen. Some anura do not lay their eggs in the water, but attach them to trees, or lay them in holes near ponds, which may become filled with water after heavy rains, or lay them under dead leaves in moist situations.

The development and formation of the germinal layers of the Batrachia has chiefly been studied in the frog. In it the segmentation of the ovum results in the formation of a vesicle, the cavity of which is situated eccentrically, the roof of the cavity being much thinner than the floor. The cavity is the segmentation-cavity. The roof is formed of two or three layers of smallish pigmented cells, and the floor of large cells, which form the greater part of the ovum. These large cells are the yolk-cells, and are part of the primitive hypoblast. The cells forming the roof of the cavity pass into these cells without any line of demarcation, but, at the junction, are a few cells of intermediate character. The cells both of the roof and floor continue to increase in number, and those of the roof become divided into two distinct strata. The upper row of these is formed of a single row of somewhat cubic cells, and the lower of several rows of more rounded cells. Both of these strata eventually become the epiblast, of which they form the epidermic and nervous layers. The roof of the segmentation-cavity seems to be entirely constituted of epiblast. The next changes which take place lead to the formation of the mesenteron, and to the enclosure of the yolk-cells by the epiblast. The mesenteron is formed, as in the lamprey and lepidosteus fishes;

by an unsymmetrical form of invagination. This first commences by an inflection of the epiblast-cells for a small arc on the equatorial line, which marks the junction of the epiblastic and yolk-cells. The inflected cells become continuous with the adjoining cells. The region where the inflection is formed constitutes a kind of lip, below which a step-like cavity is soon established. This lip is equivalent to the embryonic rim of the elasmobranch blastoderm, and the cavity beneath it is the rudiment of the mesenteron. The mesenteron now rapidly extends by the invagination of the cells on its dorsal side. These cells grow inwards towards the segmentation-cavity, as a layer of cells several rows deep. At its inner end, this layer is continuous with the yolk-cells, and is divided into two strata—one of several rows of cells adjoining the epiblast, which becomes the mesoblast, and another of a single row of more columnar cells, lining the cavity of the mesenteron, which forms the hypoblast. The inward growth of the dorsal wall of the mesenteron, though in part a true invagination, is probably also due in large measure to an actual differentiation of yolk-cells along the line of growth. The mesenteron is at first a simple slit between the yolk and hypoblast; but, as the involution of the mesoblast and hypoblast extends further inwards, this slit enlarges, especially at its inner end, into a considerable cavity, the blind end of which is separated from the segmentation-cavity by a narrow layer of yolk-cells.

In the course of the involution, the segmentation-cavity becomes gradually pushed to one side, and finally obliterated; but before this occurs, in some forms, it seems to become completely enclosed in the yolk-cells. While the invagination to form the mesenteron has been going on, the enclosure of the yolk has been rapidly taking place. It is effected by the epiblast growing over the yolk at all points of its circumference. At the embryonic rim, it takes place by the simple growth of the rim; but, at other parts, the epiblast at first extends over the yolk, as a typical epibolic gastrule, without being inflected to form a definite lip. While a considerable patch of yolk is still left uncovered, the whole of the edge of the epiblast becomes, however, inflected, as at the embryonic rim; and a circular blastopore is established round the whole edge, of which the epiblast and intermediate cells are continuous. The mesoblast, derived from the small intermediate cells, grows inwards from the ventral lip of the blastopore, till it comes to the segmentation-cavity. The growth is not, however, so much due to an actual invagination of cells at the lip of the blastopore, as to a differentiation of yolk-cells *in situ*. Soon after this, the plug of yolk which fills up the opening of the blastopore disappears, and the mesenteron communicates freely with the exterior by a small circular blastopore. The blastopore is situated at the hinder end of the embryo. By this stage, the three layers of the embryo are definitely established. The epiblast arises from the small cells forming the roof of the segmentation-cavity, and consists, from its earliest formation, of two layers or strata. It becomes continuous at the lip of the blastopore, with cells intermediate in size between those of which it is formed and the yolk-cells. These latter, increasing in number by additions from the yolk-cells, give rise to the mesoblast, and to part of the hypoblast, while the yolk-cells must be considered to belong to the hypoblastic layer.

ST. JOHN AMBULANCE ASSOCIATION.—At a meeting of the Central Executive Committee, held lately at St. John's Gate, Clerkenwell, Colonel Sir Henry Loch, K.C.B., Commissioner of Woods and Forests, in the chair, it was reported that, at a recent inspection of the Egyptian Artillery by General Sir Evelyn Wood, the men went through a demonstration of the stretcher-drill of the St. John Ambulance Association, which had been introduced by the commanding officer. The demonstration was subsequently repeated in the presence of the Khedive, who expressed himself as greatly pleased with the men's progress. It was further reported at the meeting that 504 members of the Metropolitan Police had entered their names for a fresh course of instruction in and near London, and that 149 men of the same force attached to Devonport Dockyard were ready for examination. The Metropolitan Fire Brigade classes had been examined, and forty-five certificates awarded; among the successful candidates being Captain Shaw and other officers. Many meetings for the distribution of certificates had been held in various parts of the country during the past month, the most notable one being at Dublin, attended by over 1,000 persons. The presentation was made by Countess Spencer. New centres had been formed at Gibraltar, Bridport, Eastbourne, Cork, Bedford, and other places.

THE Duke of Westminster has contributed £100 to the fund for completing the buildings of the London Temperance Hospital, situated in the Hampstead Road.