former position. So, in the administration of chloroform, experience has taught that neither a perfectly empty nor a very full stomach is desirable. My friend Steggall of Queen Square has informed me that, having occasion to give chloroform to a child previously to the performance of an operation, he was surprised at the appearance of very alarming symptoms when but a moderate dose of the anæsthetic had been given. From these the child was happily and quickly relieved by rejecting from the stomach a large quantity of rich plum-cake which the child had, without the knowledge of the operator, eaten but a short time before. Facts like these direct the attention to the eighth pair of nerves; and I remember that, so long ago as in 1821 or 1822, I wrote a juvenile essay, the subject of which was the section of these nerves, in which I expressed the opinion that death, not being the immediate consequence of the simultaneous division of both nerves, was to be attributed to the maintenance of voluntary respiration for some hours after involuntary respiration had ceased.

Having commenced but not completed committing these reflections to paper before starting for a journey on the continent, I have had an opportunity of conversing upon the subject with my friend Dr. Foville, whose attention is well known to have been long turned to the anatomy, physiology, and pathology of the brain and nervous system, and whose abandoning of the completion of his work is a grievous loss to our profession. The doctor, after patiently hearing my statement, was so far from rejecting my ideas, that he related a case tending to confirm them. A patient of his, labouring under some form of paralysis which ultimately occasioned his death, complained of being distressed with nightmare on falling asleep. The doctor, having an opportunity of watching the approaches of the paroxysms, observed that his respiration became interrupted, and then suspended, which resulted in his waking up in agitation and fright. Attention to position in his sleeping state to some degree, but imperfectly, prevented the paroxysms. Dr. Foville further told me, in reference to what I had said regarding the eighth pair of nerves, that Professor Blainville had made some experiments on the section of them, in the course of which he observed that the death of the animal was accelerated if it were placed on its back, but retarded by the chest being downwards, as when it is in the standing position; which seems to coincide with the need to facilitate and maintain the voluntary efforts at respiration.

In close relation to the points upon which I have here touched, I would take leave to add a few words of a practical tendency, though I fear they may be regarded by some as crotchety. It is well known that ether and chloroform have very conspicuously the power of averting or greatly mitigating the paroxysms of spasmodic asthma, which they probably do by blunting the exaggerated perceptions, the normal and healthy action of which call for and determine the involuntary movements of respiration. If, on the other hand, their influence be superadded to a state approaching to morbid, and in which these perceptions are too feeble, we may expect the symptoms which occur when the influence of chloroform is alarming or even fatal. I have repeatedly noticed that medicines which contain ether or chloroform, although at first very agreeable, as is especially the case with the latter, have a decided influence in disturbing the stomach and producing indications of indigestion; whilst an influence diametrically the reverse of this is produced by brandy and other nearly pure alcoholic spirits. Hence their frequent employment to correct the stomach, and the abuse thereby induced. This conviction as to the effect of ether, etc., has made me for a long time averse to the use of etherial medicines, though so commonly resorted to as antispasmodics. Here also we may suspect that the influence is exerted through the eighth pair of nerves.

Though I have not and at present cannot consult medical authorities, I must observe that, a short time before leaving home, I read part of a paper relating to the agency of chloroform in the British Medical Journal. It went far in support of the views which I have long held, and have here endeavoured to sketch. I think it was by Dr. Kidd, and bore chiefly on the employment of chloroform in obstetrics. The condition very suitably designated as *apnœa* seems to be exactly that to which I have here referred. I am sorry that I omitted to look to the other portions of the same essay, given in different numbers of the periodical.

Marseilles, 30 Imo., 1863.

PATHOLOGICAL AND PRACTICAL RESEARCHES ON THE VARIOUS FORMS OF PARALYSIS.

By Edward Meryon, M.D., F.R.C.P.

[*Continued from page* 478.]

The anatomical connection between the sensitive posterior columns of the spinal cord in their entirety and the cerebellum, the extension of nerve-fibres from the cerebellum to the corpora quadrigemina, and from these bodies to the optic thalami, are facts which indicate the existence of close physiological relationship between these parts. And I venture to assume that it is through these channels that objective sensations are conveyed to the cerebrum, the centre of volition; that from the ganglionic cells contained in the corpora striata and optic thalami, the mandates of the will are extended through the vesicular matter of the crura cerebri, of the pons, and of the medulla oblongata, to the anterior horns of grey matter contained in the spinal cord by means of the corpora pyramidalia and the anterior columns of the cord, the fibres of which communicate directly or indirectly with the ganglionic cells of the anterior cornua, which become the excitors of muscular motion; and that the transverse fibres in the mesocephale and medulla oblongata, which are almost, if not quite as numerous as the longitudinal, serve as conductors of the orders of the will to the nuclei of motor nerves, for the consentaneous action of corresponding muscles in the movements of the face and tongue for expression and speech, in the contraction of the gullet for deglutition, and in the movements of the ribs for respiration.

But how are these several acts performed? In other words, what is the nature of that mysterious nerve-force which, beginning its physical career in the organs of sense, passes to the sensorium, where it becomes an object of consciousness, and, operating on the cerebrum, engenders actual ideas or volitions which are transmitted to the spinal cord, and there excite muscular motion?

Is it simply electricity, in the development of which every minute molecule of nervous matter, by virtue of a dipolar attribute, adds its quota to the evolution of an electric current? Or is it some other power which may be represented by a given quantity, say of heat, which would be required to raise the temperature of a given quantity of water so many degrees as to produce a certain amount of mechanical energy or motion?

Many physiologists have embraced the latter opinion, chiefly in consequence of the different behaviour of a muscle when under the influence of a nerve in a physiological active state, and when artificially placed in an electrotonic state by the transmission of a constant galvanic current through it. In the first case, the muscle is kept in a constant state of contraction; in the electro-tonic condition, contraction occurs only on closing and opening the circuit. In the interval, the muscle is in a state of relaxation, and remains so.

This objection to the electric theory of nerve-force has been met by the proposition, that animal electricity may exist in a static form; but Pflüger's investigations, to which I shall immediately have to refer, have resulted in the establishment of a theory of nerve-excitation, strictly in accordance with the laws of muscular contraction.

Electricity is developed in some animal tissues in direct proportion to the size of the nerves; and M. Armand Moreau has recorded many experiments to prove the identity of the agent discharged from the electric organ of the torpedo, with that discharged from a Leyden battery. (*Experiences sur la Torpille Electrique. Annales des Sciences Naturelles*, 4e serie, t. 18. 1862.)

Furthermore, it is well known that the galvanic current can be made not only to imitate the natural nerve force, but that it may also replace it in producing many of the phenomena of life; and that these latter can only be explained by supposing that the development of nerve action is associated, if not identical with the assumption of a polar condition by the molecules of nerves.

In my history of medicine, it will be my duty to refer to many Italian physicians who have established these facts, but to no one more than to Professor Matteucci, of Pisa, who has shown that a galvanic current affects both sensitive and motor nerves to a greater degree when the current is made to pass through either in the direct or natural course of the nerve force (centripetal in sensitive nerves, centrifugal in motor nerves) than when it is transmitted in the inverse or opposed course; that the excitability of motor nerve-fibres is modified by their juxtaposition with sensitive nerve-fibres (most nervous trunks being composed of both); and that electricity is developed during muscular contraction.

All these facts have been investigated by M. Du Bois Reymond, whose great work on *Animal Electricity* forms a second era in that science. All his experiments have been conducted with a galvanoscope, by means of which he has established the fact that every molecule of fresh excitable nerve is the source of electro-motive power; and that every part of a nerve acts in obedience to the same law as that which governs the function of the entire nerve.

He supposes that every nerve consists of a number of dipolar molecules arranged in couplets, and that in a state of rest the similar poles of each pair of molecules are turned towards each other, so as to represent the condition of a closed current, the negative poles being turned towards the extremities of the nerve.

In the active or electrotonic state he supposes that an electrolytic process takes place, and that the molecules arrange themselves so that the opposite poles are turned towards each other; the negative pole (—) being turned towards the point at which the current enters, the positive pole (+) towards the point at which the current leaves the nerve.

Du Bois Reymond has also suggested that, in a state of rest, each nerve molecule may have its external surface in a positive, and its internal part in a negative state of electricity; and that excitement or irritation may induce an opposite state of polarity, namely, a negative condition of the external and a positive state of the internal part of each molecule—an active or electrotonic state.

Now, if the sciatic nerve of a living frog be dissected out from the muscles of the thigh and the thigh removed, so as to leave the nerve in connection with the spinal cord above, and with the leg below, when the nerve is placed on the cushions of a galvanoscope, it produces a deflection of the needle.

If through the same nerve a constant galvanic current be passed in the same direction as the nerve-current, an immediate increase of the deflection of the needle takes place; but if the current be passed in the opposite direction to the nerve-current, an immediate decrease of the deflection is observed.

The reason assigned by M. Du Bois Reymond is obvious. In the first case, the superinduced current is just so much added to the original nerve force, in the second, it is just so much subtracted or neutralised by the opposed current.

On further investigation, by placing a transverse section of a nerve in contact with one cushion of the galvanoscope, whilst the longitudinal surface rested on the other, a strong deflection of the needle indicated the course of an electro-motive current passing from the external surface to the transverse. Hence, the external surface is shown to be positive (+) in its electric relations with the transverse which is negative (—).

From this and other corresponding observations, M. Du Bois Reymond inferred that the power in question acts according to a definite law which may be stated as the law of antagonism of the longitudinal and transverse sections, the former being positive, the latter negative.

All this, however, did not diminish the objection which has been stated to the electric theory of nerve-force; therefore, M. Du Bois Reymond instituted other experiments, and discovered that if, instead of a continuous galvanic current, a series of instantaneous currents of high tension electricity (Faradaic currents) be made to pass along a nerve connected with a muscle, the contractions follow each other so rapidly that the muscle has no time to regain its state of relaxation, and a condition of continued contraction, like that of tetanus, is the result.

When examined by the galvanoscope, this interrupted current occasions the positive and negative deflections of the needle, but the positive variation is less than the negative (in the constant current the positive variation is greater); hence it would appear that in the tetanised nerve the characteristic phenomenon is expressed by a negative deflection.

The question remains, is the tetanised nerve identical in character with the physiological active nerve? If it be, then a negative deflection of the needle is the expression of the natural nerve-current.

At this point Pflüger began his researches, by examining the effects of a constant galvanic current varying in strength; and he discovered that, by the weakest current he could establish, a continuous contraction of muscle may be produced; that by a stronger current, but still so weak as barely to deflect the needle, tetanus may be produced; and that a very powerful current produces no contraction at all, except at the moment of closing and opening the circuit, the opening being followed by weak contraction only. Hence, he infers that the most important consideration in conducting these physiological experiments is the strength of the current employed; that an extremely weak current is the function of an active healthy nerve; and that a very powerful current suspends the action, and perhaps even causes the death of the nerve-molecules. (*Untersuchungen über die Physiologie des Electrotonus.* Von Eduard Pflüger. Berlin, 1859.)

He has furthermore shown that the phenomena of action, so far as the sensitive nerves are concerned, are the same as those in motor nerves, the direction of the current being of course reversed. A very weak centripetal constant current produces pain; a very powerful current produces no pain. There is, therefore, every reason to suppose that the law of excitation in the sensitive nerve is analogous to that of the motor nerve.

In further illustration of this, Matteucci's experiments may be here mentioned. He has shown that by exposing a mixed nerve, say the sciatic, and by applying the positive pole of a weak galvanic current towards the spinal end, and the negative pole on the peripheral end of the exposed portion of nerve, muscular contraction occurs, but no pain. If, however, the poles be reversed

so that the positive is brought into contact with the peripheral end, and the negative with the spinal end of the exposed nerve, then pain is produced, but no muscular contraction.

The peripheral termination of motor nerves, as connected with the ultimate muscular fibre, is a most interesting subject of inquiry. Kühne supposes that the neurolemma always joins the sarcolemma, and that the nerve-molecules pass beneath the sarcolemma so as to come into intimate contact with the contractile substance. To these nerve-molecules he has given the name of peripheric nervous nodules.

Dr. Lionel Beale contends that the nerve-fibre is far more extensive than is supposed by Kühne; that it extends into the interstices of the ultimate muscular fibres in the form of a most elaborate network; that the nerves never lose themselves in other tissues, or become continuous with them; that they are brought into close relation with muscular fibre by their nuclei, but never lose their distinctness as special nerve-tissue. And I think he is right.

If, then, we admit the existence of a current of nerve-force, we must also admit that every act of muscular contraction and every perception of sensation involve a given expenditure of nerve-force; a disturbance of electric equilibrium along the whole course of the nerve, and a corresponding movement to restore the equilibrium, an inverse sequence of phenomena being understood; namely, a centrifugal disturbance in the case of muscular motion, a centripetal disturbance in the case of sensation, and in each case an inverse reaction to establish the equilibrium.

Pflüger's experiments have led him to conclude that one and the same irritant applied to a nerve acts more powerfully the further it is applied from a muscle, in the case of a motor nerve, or from the spinal cord in the case of a sensitive nerve. His idea is, that a progressive molecular movement is developed at all points of a nerve; so that the sum of force is greater at the extremity of a nerve, along which an irritation has travelled, than at the point where the irritation was applied.

Whatever the peculiar nature of the nerve-force may be, we know that muscles cannot act singly, but that the cooperation of a group is necessary to perform every movement of the body, whether it be made for locomotion, respiration, deglutition, or any other special motion for which the muscles are intended; and there is great reason to suppose that such consentaneous action results from the functional activity of separate groups of ganglionic cells in the spinal cord (each group being strung together by nerve-fibres like the jars of a Leyden battery) which transmit their influence through the motor nerves. Each group is probably excited to action by a longitudinal nerve-fibre which conducts the mandates of the will to the organ of coordination; and thus the telegraphic nerve-fibres in the anterior columns are relatively few to the number of motor nerves which proceed from the spinal marrow.

Sympathetic Nerves.

The physiological researches of Professor Bernard and others, have led to the conclusion that the sympathetic nerves are motor nerves of blood-vessels—vaso-motor nerves—and that they form a complementary organism, placed by the side of the cerebro-spinal axis, communicating with it, endowed with similar attributes, obedient to the same laws, but exerting their action on different tissues.

In 1851, Professor Bernard showed that a section of the cervical portion of the sympathetic nerve is always followed by a dilatation of the blood-vessels, and an increased afflux of blood in those parts of the head to which the sympathetic nerve is distributed. In 1852, Dr. Brown-Séquard demonstrated the converse; namely, that either direct or reflex excitation of the sympathetic nerve by galvanism is followed by a contraction of the blood-vessels and a diminished afflux of blood. Again, in 1857, he showed the resemblance between the effects of a section of the sympathetic nerve in the neck and a transverse section of a lateral half of the spinal cord. In both cases a paralysis of the vascular nerves, and therefore a paralysis of the blood-vessels, is induced; there is a greater afflux of blood in those vessels to which the divided nerves are distributed; nutrition is increased, and the vital properties of nerves, muscles, and blood-vessels are augmented. Many points of resemblance are also found, on comparing the side of the face where the sympathetic nerve has not been divided with the posterior limb of the uninjured side of the spinal cord. Both receive less blood than usual; in both the temperature is diminished, and the vital properties of both are decreased.

By the doctrine that the blood-vessels and secretory organs are dependent on the influence of the sympathetic nerves, almost all physiological and pathological phenomena which have hitherto been obscure, admit of an explanation. Moreover, some experiments which Professor Wagner has lately made upon the head of an executed criminal, tend to prove that the contraction and dilatation of the pupils are due to the influence of the sympathetic nerves. The head was cut off by the guillotine, the blade of which passed through the sixth cervical vertebra; and, eighteen minutes afterwards, the experiments were commenced. An electro-magnetic current was applied to the divided end of the great sympathetic trunk, first on one side of the neck, and then on the other. The eyelids of the corresponding eye were observed to separate, and the pupil to dilate, until the breadth of the iris did not exceed four-fifths of a line. The experiment was repeated six times in twenty-five minutes, and always with the same result. After the nervous trunks had become insensible, the superior cervical ganglion was laid bare, and similar results were obtained on applying the magneto-electric current to it. (*Zeitschrift für Rationelle Medicin*, 3e serie, bd. 5, Nos. 2 and 3.)

[*To be continued.*]

ON DIPHTHERIA.

By J. West Walker, M.B.Lond., etc., Spilsby.

The study of diphtheria is a subject of the greatest possible interest and importance. It is interesting on account of the comparative novelty of the disease, and of the as yet unsatisfactory state of our knowledge bearing upon its pathology and treatment; and, when we reflect on the terrible mortality with which it is so frequently attended, its importance, I think, can scarcely be overrated. Happily of late this mortality, which occurred more especially during the climax of the epidemic, has considerably diminished; the disease, however, still continues to prevail extensively, keeping the public mind in a state of anxiety and alarm, and justifying, I trust, any one who shall endeavour to contribute, however slightly, towards a better understanding of its true nature.

As might be expected, a visitation so serious has greatly aroused the observant faculty of the profession; and thus facts have been abundantly accumulated and recorded, and speculations the most opposite and conflicting, freely and confidently promulgated. To attempt to generalise somewhat these facts, and reconcile these opinions, is what I propose to myself in the present paper.

By some, by far the greater number of my professional brethren, diphtheria is looked upon as a distinct acute specific disease, having general and local symptoms; and this is the view which justifies our great nosologist Dr. Farr, in giving to it its present name and place in his classification of diseases. By others, again, it is believed to be but a modification of some one of the previously recognised diseases—of common epidemic sore-throat, of