of the jaw which is greatly on the increase, and which, if ill-managed, results in a state of much discomfort and disfigurement, to say nothing of any ulterior consequences in the health. This change, which Dr. Coffin speaks of in terms of "consternation," is a tendency to contraction of the sockets, especially in the upper jaw, with narrow and high vaulted roof or palatine cavity, alterations in the dimensions of the antrum or maxillary sinus, and contracted nasal passages. This gives the feature of acute angular, or "prognathous" facial aspect, and close approximation of the canine, bicuspid and true molar teeth. Thus mastication, speech and beauty are interfered with, and dental caries and neuralgia, on the contrary, are encouraged."

It would be useful to know in what proportion of cases this abnormal appearance of the jaw is present with those not mentally affected. I had designed making some remarks upon the abnormal shape of the spheno-basilar bone described by Virchow and others in the crania of Cretins, and the enlargements of the jugular foramina occasionally described in those afflicted with the same disease, but fear that this would require more space than I could at present venture to claim.

The Functions of Brain and Muscle, considered in relation to Epilepsy. By J. Thompson Dickson, M.A., and M.B. (Cantab), Lecturer on Mental Diseases at Guy's Hospital.

The object of this paper is to discuss some of the opinions which have recently been expressed as to the nature of Epilepsy; and in particular, the views of Dr. Hughlings Jackson, who regards the epileptic phenomenon as the result of a "discharge" from a damaged portion of the brain, which he speaks of as a "discharging lesion."*

In November, 1867, I published a paper in the "British Medical Journal" on a case of "Petit Mal" in a girl who cut her throat whilst passing through the phase of mental disturbance which is frequently associated with that form

* "On the Anatomical and Physiological Localization of Movements in the Brain." By J. Hughlings Jackson, *Lancet,* January 18th, 1873.
"Anatomical, Physiological, and Pathological Investigation of Epileptics." By J. Hughlings Jackson, M.D., West Riding Lunatic Asylum Reports, Vol. III., 1873. Also a paper in the *Medical Times and Gazette,* November 30th, 1873.

of Epilepsy, and in that paper I attempted to illustrate two ideas; the first, that the seat of the lesion to which the epileptic phenomena are due is the surface of the brain, whence we get derangement of thought and disturbance of motion; the second, that these phenomena are the result of a "loss of control."

These ideas, which were drawn from a long series of observations, I stated more definitely in a paper entitled "Matter and Force in relation to Mental and Cerebral Phenomena," published in the "Journal of Mental Science," July, 1869, in which paper I remarked—"When the writhing agony of tic, the violent spasm of tetanus, or the hæmorrhagic congestion of the second stage of epilepsy are witnessed, it is not perhaps to be wondered that the *prima facie* inference should have been undue excitement and over action," but it is evident that such an idea would never have been formed had all the phenomena been carefully noted, and the evidence afforded by each carefully weighed.

"Again, what is termed nervous excitement, as instanced in the delirium of fever, the restless delirium of delirium tremens, and the apparent over action in several forms of insanity, particularly in paroxysms of mania and the excited stages of general paralysis, the ultimate exhaustion renders it evident that the over-action was not real, but due to the arrest of activity, or the diminution of the vitality of those cells wherein the function of control is vested."

"It may be laid down as a rule, that the amount of action the muscular system is capable of performing, and the amount of control which the central nervous system is capable of exercising, are in the healthy animal accurately and perfectly balanced, while any undue excitement visible to us in the former is to be received as evidence of a diminution of power or loss of vitality in the latter."

And again, in a paper summing up the results of a series of experiments on rabbits and Guinea pigs,—published in the "British Medical Journal," June 4th and 11th, 1870,—I advanced the following propositions:—

1.—Epilepsy is a contraction of the cerebral capillaries and small arterial vessels; the order of its stages in epileptic attack are, 1st, irritation of the brain, either direct, or secondary to exhaustion; 2nd, contraction of cerebral capillaries and small arterial vessels; 3rd, cerebral anæmia, and consequent loss of consciousness.

2.—The muscular contraction and spasm, together with

all the varying phenomena associated with epilepsy, are altogether secondary, and not at all essential or constant, but they are all manifestations of imperfect nervous (cerebral) control, or a loss of balance between the nervous and other systems, and after reviewing the evidence I had adduced I concluded with the statement—"Epilepsy is loss of consciousness, the result of contraction of the cerebral smaller arteries and capillaries, induced by irritation, either direct or secondary to exhaustion. Epilepsy may be attended with an endless variety of phenomena, all of which are manifestations of an arrest of control. None of them are essential, and all are dependent upon accidental cause."

The same view I have advanced in several later papers, and in one, "On the Dynamics of Epilepsy and Convulsions" in the Guy's Reports, 1873, I generalised further on the subject of local epilepsy, of local lesions, and loss of control from circumscribed portions of the brain surface, and I commented upon Dr. Jackson's view of "discharges from a pathological seat," or "explosions of nerve force." In the commencement I would briefly enumerate the general points of argument upon which practical physiologists and pathologists are now generally agreed in regard to epileptic phenomena, and it is but due to Dr. Jackson to record that his careful observations have added largely to our knowledge on the subject.

The first point to be noticed is the seat of the lesion or lesions upon which the epileptic phenomena depend, and this seat we know with certainty to be the surface of the brain. Some of the earliest observations were made by Dr. Bright. Afterwards Dr. Wilks pointed out that tumours of the surface of the brain were associated with epilepsy. Dr. Hughlings Jackson stated the same fact. After recording numerous observations confirming this general view in the dead-house, I searched the *post-mortem* books at Guy's for ten years, and the cases therein detailed also bear witness to the same truth, and my experiments in the artificial production of epilepsy led me to the same conclusion. The fact has been made plainer still by Professor Ferrier, who, with the view of putting to experimental proof the statement of Dr. Jackson, that "epileptiform seizure may be looked upon as experiments on the brain made by disease, revealing to us the localisation of special classes of movements in the cerebral hemispheres," following up the researches of Fritsch and Hitzig (who have shown the brain to be susceptible of galvanic stimulation)—lately undertook an investigation, the details of

which are recorded in the West Riding Lunatic Asylum Medical Reports for 1873. He induced epilepsy in cats and rabbits by faradisation applied to the cerebral surface, and demonstrated at the same time that certain convolutions are associated with special muscular movements. By Professor Ferrier's experiments certain convolutions have been proved to preside over definite muscular regions, as the lips, the paws, the mouth, &c.; and it is but a step to the association of the convolution presiding over the movements of the tongue and lips in articulation with the thoughts expressed in the utterance, and thence to thought generally. Professor Ferrier's experiments, in addition to producing local epilepsies, frequently induced general epilepsies, but as the stimulus of electrolization produces intense local hyperæmia he did not observe, nor indeed was it possible for him to observe in his experiments, the condition of anæmia which goes with the attack. That the brain does become anæmic, by the sudden contraction of the smaller arterial vessels has, I think, been sufficiently shown—it obtained in the experiments of Kussmaul and Tenner, it appeared in my own experiments, and it has been observed by numerous experimenters, whilst the pallor associated with the invasion of Epilepsy, which goes with the cerebral anæmia, has been remarked by all recent clinical observers; and, in particular, it was insisted upon by Jules Falret and by Trousseau. The absence of evidence from Ferrier's particular and exceptional experiments on this head cannot be taken as any proof of the correctness of the theories of those who regard congestion of the brain as essential to the production of Epilepsy, the nature of the experiments being a bar to the observation much in the same way as the black skin of a nigger is a veil to the nigger's blushes.

The fact of the contraction of the vessels at the time of the seizure may be demonstrated by examining the brain by Donders' method.

I now propose to review some of Dr. Jackson's statements in his paper "On the Anatomical, Physiological, and Pathological Investigation of Epileptics."

In the first place Dr. Jackson starts with the statement that the "Normal function of nerve tissue is to store up and expend force," and he says, "It is true that this is the function of *all* organic matter, but it is *par excellence* the function of nerve tissue. There are *but two* kinds of alteration of function from disease. Saying nothing of degrees of each, there is

on the one hand loss of function, on the other over-function (not better function). In the former, nerve tissue ceases to store up, and therefore to expend force. In the latter, more nerve force is stirred up than in health, and more is therefore expended; the nerve tissue is "highly unstable."

But we may ask, what is the proof that the normal function of nerve tissue is "to store up and to expend force?" By what means does it store it up? how is it expended? and by what mode of motion is this force to be expressed? Dr. Jackson answers some of these questions; he says "there are many varieties of discharges. Defined from paroxysm, an Epilepsy is a *sudden*, excessive, and rapid discharge of grey matter of some *part* of the brain; it is a local discharge. To define it from the functional alteration, we say there is in a case of epilepsy grey matter which is so abnormally nourished that it occasionally reaches very high tension and very unstable equilibrium, and therefore occasionally 'explodes.'"

Now this statement involves the notion that the nerve forces behave as statical electricity, that it is capable of being accumulated in the cells of the grey substance of the brain, as the electricity is accumulated on the surface of the glass plate, and that it discharges or explodes in the same manner as electricity discharges from an electrophorus or a Leyden jar. That such should occur is not only improbable, but impossible. The brain is not even a voltaic battery. Still less is it a statical electrical machine. Those who would consider it as a galvanic apparatus have only to compare it with the electrical lobes of the torpedo, to see that there is no alliance; and though certain deflections of the galvanometer needle have been obtained in experiments upon brain and nerve, there is no proof that these deflections resulted from galvanic currents proceeding from the brain as a battery; indeed, it seems much more likely that they were Thermo-electrical currents developed in the course of the experiments. In whatever way nerve force may be correlated, it certainly is not identical with galvanism; still less is it identical with electricity. Therefore, the idea of sudden and rapid discharges, unstable equilibria, and explosions must be put out of the category.

Dr. Hughlings Jackson quotes Herbert Spencer ("Psychology," vol. i, p. 90), in support of his view, and states that "the following remarks, referring to healthy discharges, would, with a few modifications, apply to some of the trifling degrees of instability of disease." The longer repair goes

on unopposed by appreciable waste, the greater must become the instability of the nerve centres, and the greater their readiness to act; so that there must at length come a time when the slightest impressions will produce motions. "In fact," says Dr. Jackson, "there is at the time Spencer is speaking of a healthy and yet random discharge. On awakening from refreshing sleep there commonly occurs an involuntary stretching of the whole body, showing an immense undirected motor discharge" (Spencer, op. cit., vol. i, p. 90). "And," Dr. Jackson adds, "then a sneeze is a sort of healthy epilepsy." From this it would seem that Spencer holds somewhat the same, though the untenable view, that nervous force can be accumulated by and discharged from the brain like statical electricity. The involuntary stretching of the muscles on awakening from sleep is not due to electrical mandates discharged at random from the brain as electricity from a highly charged machine. The stretching of the muscles is not altogether involuntary, but results from the feeling of necessity of changing the position—the muscles ache from the weight of the body pressing upon them whilst the body is in the recumbent position—also from having been long in one position, and a semi-voluntary movement or general extensor contraction takes place or is permitted in consequence. To ally this condition to epilepsy is to associate two almost opposite conditions; but to make sneezing "a sort of healthy epilepsy" is to make every one epileptic, which cannot be admitted.

That the nerve-cells are capable of storing up motion (I use the word in its abstract sense, meaning thereby that which we can correlate and express in modes, as heat, light, chemical force, &c., &c.) in some mode or modes is only in a very limited sense true; nerve tissue, like every other tissue, undergoes the changes of wear and repair, but whatever be the mode of motion which regulates these changes, whether it be termed vital—regarding vitality as a mode of motion—or whether it be called by any other name, we have positive evidence that the principal modal changes which go on in the brain are chemical. Material is taken up in nutrition, and material is expended in wear and tear, but by processes so uniform that they hardly vary with the changes of rapidity in the circulation.*

* This fact alone is additional evidence on the point of control: increase the circulation, there is no loss of control and no epilepsy; cut off the blood supply to the brain, and the immediate result is epilepsy, the arrest of blood supply paralysing the control by discontinuance of the nutreant supply and materials for chemical change.

In epilepsy we get violent muscular manifestations, but there are no violent changes going on in the tissue of the brain. The utmost degree of violent motion the brain is capable of is the sudden contraction of its vessels, and this is a muscular movement. Explosive discharges such as Dr. Jackson's view involves would soon shatter the brain and kill the patient; but epileptics commonly recover from their attacks, and they recover because the violence we witness occurs not in the brain, but in the muscles and limbs.

The function of muscle is contraction and movement, and when muscles are perfectly normal they will, if liberated from control, perform their function spontaneously, and they will continue to perform it until their potential energy is exhausted.

The new-born infant moves, and the young cow or the young horse move, not from mandates sent to their muscles from their untutored brains, but from spontaneity, or the tendency of the healthy muscles to perform their function.

The infant muscles move from spontaneity, and the movements are, so to say, noted by, or form impressions upon the brain. Spontaneous movements are repeated, and again an impression is conveyed to the brain, and noted in the brain-cells; the direction is noted, a specific pleasure is derived from a certain motion which is also noted, and the pleasure and the movement become thereby associated, and grow together, till at length they, together, develop that which we call volition or will, and thus, by schooling and tutoring, the muscles come under voluntary control. Undoubtedly the seat of control over each muscle is the region or spot in the grey matter of the brain wherein its first motions were recorded, and which thenceforth was destined to become the controlling centre of its motion. It is highly probable that to spontaneity of movement, and to the registration of movements by the brain, we owe not only the rudiments of volition out of which all controlled and directed movements are differentiated, but we owe our thoughts also to the same, or to analagous phenomena in a greater or less degree.

The familiar illustration of Aphasia is valuable in showing the association of the local seat of verbal expression, and the control over the muscles, brought into play in articulation; destroy the seat of these expressions (the seat appears to be the third frontal convolution of the left side), and not only is articulation impossible, but the knowledge of the words is gone, and is not recovered, unless, as Dr. Moxon* has shown,

* British and Foreign Medico-Chirurgical Review, April, 1866.

the other side be educated. You may get spasmodic movements in the muscles of articulation after the seat of control is lost, but the directed movements of speech from the muscles cannot, except under certain conditions, be recovered.

That we may have loss of function of any organic tissue is perfectly true, but that we ever have over function does not seem to me to be strictly physiological or possible. It is true that we may get compensations—one organ will increase in size to compensate for the loss of some other organ, as in the case of one kidney increasing in size when the other has been lost; or we may have increase in size to overcome obstruction, as in the case of the heart. But that a tissue like the brain should "store up more nerve force than in health" seems to me to be impossible. The moment you overstep the limit of health you pass into the region of weakness, you do not increase the strength; and any storing up will be, not of material capable of exercising an excess of function, but of effete material, as fat or salts. I was asked one day, by a doctor, whether the hypertrophy of the heart, in one of his patients who I saw with him, was due to over-nourishment, the patient being rather a large eater. The two ideas are very much on a level. The patient had bad vessels.

The heart of a highly fed, indolent man may become large and fatty, but it certainly will not gain strength or capacity for function thereby; on the contrary, it is badly nourished, it will become weak, and the performance of its function will become irregular and imperfect in consequence. In the same way the brain, when badly nourished, becomes weak, and if it stores up any material, that material is fat or amyloid substance, or perhaps calcareous salts; certainly not material for increased function.

The function of such a brain is interfered with, and is irregular (or ceases), and as the healthy brain's function is not to give out discharges, but to maintain control, so the badly nourished brain, or, as I have commonly found it in epileptics, the atrophied brain loses its power of maintaining control, and the function becomes imperfect or irregular, and, under some circumstances, altogether ceases. A fact which is distinct and clear is, that the seat of the expenditure of force in any movement is in the muscles, and not in the brain. Another fact, which numerous observers appear to have overlooked, but one which bears importantly on the subject of epilepsy, was recorded by Galvani, and afterwards verified by

Niobi, is, that the set of the current in the nerves, during muscular contraction, is not in a direction from the brain to the muscle, but from the muscle to the brain. Whatever these currents may be, whether they be galvanic or vital (they can be measured with a galvanometer), the fact that they all have one direction, viz., towards the brain, at once negatives the possibility of discharges or explosions of force from the brain into the muscle.

We have seen muscles contract from spontaneity in the infant, and they would continue to perform this function spontaneously and indirectly, did they not come under the control of volition, the seat of which is the surface of the brain. It is, then, but a logical conclusion that if you remove the control, the muscles will, as in infancy, perform their function and contract by indirect effort. It requires no direct nervous stimulus from the brain to cause muscles to contract. Healthy and well-nourished muscles will contract, as is their wonted function, when the brain is removed altogether, the simplest illustrations being that of the decapitated. In such the muscles contract violently! Why? Certainly not because mandates are sent to them from the brain; but because their controlling organ has been removed. This used to be called reflex action. In a certain sense it is, for it is a reflexion from the muscles towards this controlling centre, which has been lost, but nothing more. What is more is, that the muscles, in such a case, will continue to contract as long as they remain sufficiently alive, or as long as the chemical change, associated with muscular contraction, can be maintained.

The due performance of the function of muscle appears to be dependent, in a great measure, on conditions of nutrition, partly upon innervation, and, in some measure, upon the circulation and the animation of the vessels supplying the muscles. In man, and in many other vertebrate animals, the time during which the muscles retain their function, after their nervous supply has been cut off, is short—but that they do retain it for a short time is remarkably seen when a man is beheaded; he will kick and strike his arms out violently after the head has been severed from the trunk. When the neck of a bird or fowl has been dislocated the muscles always contract convulsively several times, and some degree of general convulsion invariably occurs when the brain of any animal is separated from the cord; in other words, when the control is taken off the muscles. In some few animals certain

muscles will continue to contract for a considerable time after they have been removed entirely beyond the influence of the brain or of nervous stimulus. The heart of a rabbit will continue to beat long after the spinal cord and brain have been severed from one another, and the hearts of Batrachia and some Reptilia, as Tortoises and Turtles, will beat for a considerable time after they are removed from the body, and, as Professor Marey has lately shown, the force of the contraction is directly proportionate to the amount of resistance, and not to nervous stimulus.

We may, therefore, from the evidence we have, conclude definitely that the muscular contraction and spasm in epilepsy is the necessary consequence of a loss of cerebral control. If the damage be in one convolution only, we may have a local muscular contraction; if the lesion be in more than one, we may have contraction in several regions, and if the exhaustion, which determines either the periodical or the irregular attacks, becomes considerable, the whole brain may become anæmic, and the convulsions may then become general.

In the event of the local convulsion, the muscular contraction will cease when the potential energy of the muscle is exhausted, and it may begin again when the potential energy has been restored by rest and nutrition, but this depends upon circumstances, for some amount of control may be in the meantime restored. If in the course of the phenomena arising out of the local affection the brain generally becomes weakened, we may expect the further phenomenon of the general contraction of the cerebral vessels and loss of consciousness. General convulsions may follow.

It may be asked, If the muscular contraction in Epilepsy is due to a loss of the control exercised by a convolution, or by the convolutions generally, why do we not get similar contractions of muscles with what Dr. Jackson calls "destroying lesions?" for instance, a cerebral hæmorrhage which breaks up the white matter and cuts off the convolutions from their connections. I answer that practically we do—in the first place muscular contractions are common epiphenomena of cerebral hæmorrhage; and in the second place, jactatitions are common enough in limbs recently paralysed. It may again be asked, Why, then, is the phenomenon of contraction of the muscles only occasional? why do not the contractions continue as permanent manifestations of the permanent loss of control? The answer is plain, the muscles only perform their functions when under normal conditions

of nutrition; as long as they remain healthy *they may store up material capable of manifesting "force" in its change;* but when the nutrition is no longer healthy or normal, the exhibition of function ceases. Thus in old paralysed limbs, jactatitions are uncommon, because the muscles are partially wasted. And the moment we get muscular wasting, or such a lesion in the brain as interferes with the healthy nutrition of muscle, or a lesion which damages the centres controlling the nerves governing the nutrition of the muscles, at once we get loss of function in those muscles. This will explain many of the paralyses resulting from cerebral hæmorrhage. It is at all events nearer the truth than the theory that supposes that telegraphic messages are sent from the convolutions or from the corpus striatum to the muscles prior to each contraction.

In the case of local muscular contraction or twitches, a lesion of a convolution may be slight, so that general control is maintained by the portion that remains intact, or by the help of others in the immediate vicinity; when, however, the brain begins to be exhausted (from any cause), the muscles over which the damaged portion presides will show by contraction that the control over it is lost, and the contraction of the muscles will go on until they are exhausted too. A very slight lesion in the brain's surface is sufficient for the manifestation of these phenomena, and a very little more than will allow these will permit the more profound manifestation of general contraction of the smaller vessels of the brain, and any or all of the numerous phenomena which may be included in a dramatic description of epilepsy. I think that Professor Ferrier's experiments confirm this view. He applied electrodes to various convolutions, and got contractions of corresponding muscles. Why? Not because mandates were sent from the convolution to the muscle, but because the Faradization exhausted the convolution, and the muscles contracted because they were deprived of their control. Then, again, general convulsions occurred from time to time in the course of Ferrier's experiments, these general convulsions being the result of a more or less general exhaustion of the brain from the experiment performed upon it. They certainly did not proceed from electrical force stored up in the brain. And I cannot conceive how a current of Faradization passing through the brain or through any part of it can do otherwise than effect chemical change and therewith exhaustion.

Epilepsy, however produced, whether by artificial experi-

ment or by nature's experiment (to use Dr. Jackson's language) from disease, is not a display of sudden and ruthless expenditure of stored up force, but is the manifestation of a condition of weakness and exhaustion, the primary seat of which is the surface of the brain; the exhibition of strength we further see is the loss of the potential energy of muscle, which it is the function of the nervous tissue to control and guard, and in the muscular exhaustion is to be sought the cause of temporary paralysis which often succeeds epilepsy.

There is one portion of Dr. Hughlings Jackson's paper, which I would endorse, viz., his remarks as to treatment, though I fancy we follow the same course from different starting points. I place epileptic patients upon a simple and more or less restricted diet; first, because epileptics are generally inclined to eat too much of everything, particularly of meat and highly seasoned food, and as we have to nourish brain rather than muscle I apprehend that vegetable food, and in particular cereal food, will effect that object better than meat. But I cannot go with Dr. Jackson in his view of the chemical change of the grey matter, whereby a "more explosive nervous substance is formed," nor does it seem to me to be probable that in the epileptic brain nitrogen should have displaced the normal constituent, phosphorus—chemical analysis might answer this question. But even supposing we found a deficiency of phosphorus and an excess of nitrogen, surely the nitrogen cannot have rendered the brain an explosive substance, such that its changed condition can bear any sort of comparison, even by way of illustration, to gun-cotton—and yet Dr. Jackson has hinted at such an idea in a foot note.

Before leaving the subject, I would note one interesting fact. An able paper, from the pen of Dr. J. Crichton Browne, appears in the West Riding Asylum Reports for this year, 1873, on the use of nitrite of amyl in the treatment of epilepsy. Dr. Browne's success is highly encouraging. I have used the drug with singular and striking results, and I believe that further observations will demonstrate that we have in nitrite of amyl a drug of singular value in the amelioration of the sufferings of the miserable victims of epilepsy.