were violent, remitted in a few days, but returned in eight months. Free incision through the tender spot, the wound being kept open with peas, effected complete cure.

More recently (*Medical Times and Gazette*, 1862, ii, p. 43), Mr. Downie has related a somewhat similar case, convulsive fits setting in six months after a fall which produced concussion. Here the reflex irritation appeared to be propagated through the branches of the fifth pair. The symptoms were removed by local medication.

The analogy which exists between these cases and others in which the irritation starts from a remote part of the body or limbs, is completed by an example in the *Dictionnaire des Sciences Médicales, Epilepsie*, p. 518, in which epileptic fits repeatedly ceased after a cicatrix on the scalp had been opened by caustic, but returned as often as it was permitted to heal.

There can be little doubt that, in many cases of this description, a highly abnormal condition of the nervous system generally, or of the nerves of the particular part, had existed previously. This is to be inferred from the extremely slight cause stated by Dr. Abercrombie to be able sometimes to produce such serious consequences; as, e. g., the fall of a small piece of plaster upon the head. But there is reason also to believe that, in some instances, the diseased action had extended from the superficial parts to the membranes of the brain. Thus, in a case by Mr. Crampton (*Dublin Hospital Reports*, i, 343), considerable thickening of the pericranium, resulting from a blow received six months previously, was accompanied by severe local pain, wasting paralysis of one arm with rigidity, feebleness of both lower extremities, indistinct speech, and epileptiform attacks. On operating, the bone beneath was found carious, and the dura mater was very vascular and rather thickened; it sloughed in the course of the cure. Perfect recovery was effected in a fortnight, even of the paralytic symptoms.

It is necessary that I should add, for the complete elucidation of this part of my subject, that epileptiform attacks are by no means the only symptoms which may result, independently of the effects usually referred to compression of the brain, from the injuries or other affections which have formed the subject of the preceding remarks, as will have been observed in some of the cases already quoted, particularly in the last. Thus not only severe fixed pain, but hemiplegia, apoplecticiform attacks, vertigo, defective vision, incoherence, delirium, mania, have been mentioned by authors, and especially by Mr. Guthrie, as occurring after injury to the cranium; and, in the instance of the convulsive affections themselves, other symptoms are often superadded, such as mental excitement, muscular paralysis, impairment of special sense. In many such cases, we obtain clear evidence of a reflex origin of the symptoms, by their being removed through the same agency which relieves the convulsions when they are present.

Thus Sir A. Cooper (*Lectures*, i, 309) mentions a patient who became quite insane and hemiplegic after injury to the head. A depressed portion of bone was removed by the trephine; the insanity was much relieved on the following day; the hemiplegia was gone in a fortnight. A still more striking illustration is afforded by Mr. Guthrie (page 84), in which a heavy blow on the head was followed by fixed pain in the part struck, and by impaired power in the opposite arm, ending, in eleven months, in complete left hemiplegia, and in impairment of vision, hearing, and memory. The patient was trephined; the bone was quite healthy; and nothing occurred in con-

nexion with the operation which could promise an alteration in the condition of the patient, except free bleeding from the vessels of the *diploë*. Nevertheless, she raised the previously paralysed arm several inches an hour after the operation; and sensation had returned to it. The paralysis and the affection of the senses had quite gone in three days.*

[To be continued.]

Original Communications.

ON VITAL FORCES:

THEIR PHYSIOLOGICAL AND PATHOLOGICAL APPLICATIONS.

By JAMES RHODES, Esq., Glossop.

IN a previous paper, inserted in the *BRITISH MEDICAL JOURNAL* for February 4th, 1865, I ventured to bring forward certain views on the origin of nerve or vital forces. Since then I have read with pleasure the opinions of Dr. Richardson, which he kindly pointed out in the number of this *JOURNAL* for February 25th, 1865. Our opinions are to some extent alike; yet, as we proceed, it will appear that some difference exists.

Physiologists have, with a few exceptions, hitherto considered the nerve-centres to be the true origin whence the forces or energies of the system are derived. I beg to direct attention to Dr. Richardson's "Physics of Disease" for January 7th, 1865, and to what I have already stated; and consider it necessary to introduce a few more facts which will help to convince any who cling to the old creed of the truth of our opinions.

In addition to the experiment of Grove before quoted, I think the following facts, which I here introduce, will prove the unity of forces. If we take three equal pieces of zinc, we may obtain light and heat from one piece; heat alone from the second piece; and electricity, with some heat, from the third piece. Again, the different forces thus produced from the same equivalent pieces of zinc, acted upon by oxidation, would, if collected, be equivalent one with the other; neither more nor less.

I submit that the process is alike in all three instances, and produced by oxidation. A piece of sheet-zinc will give out a bright light when burnt in a current of oxygen, or in a bright fire by blowing it; another piece, acted upon by dilute sulphuric acid, will give out considerable heat; whereas, when another piece is acted upon by diluted sulphuric acid, and connected with a copper plate or carburetted iron bar with its nitric acid bath, each of these provided with copper wires, and connected, in fact, to make a battery,—the force in this case is converted into electricity, which can be again disposed of at pleasure into simple motion, heat, and light, by varying the conditions.

With these important facts before us, we are prepared to understand the vital processes. These facts, by comparison, indicate strongly that afferent nerve-force is not generated from heat, any more than electricity is generated from heat; but that it is generated from that which, under other conditions, would generate heat.

Although the exact conditions for the generation of nerve-force in the living apparatus are not present

* My present case may be adduced as a further example; hemiplegia occurred in the course of the meningeal inflammation, the corpus striatum and thalamus being found perfectly healthy after death by microscopic examination.

as in a galvanic battery, still we have what amounts to the same thing—the same results by oxidation. By experiment we produce, from the same source, heat and electricity, just as heat and nerve-force are generated in the capillaries of the system and brain. Ganglionic nerve-fibre, and cells, accompany these minute vessels; and the oxidation of the carbon and hydrogen of fatty matters, and of albumen into fibrine, effected in contact with the walls of these vessels and the nerve-fibres, eliminates this nerve-force, to be conducted to the nerve-centres and ganglia.

Let us return to C. Bernard's experiment showing the "calorific" effect of section of the sympathetic. He considered the increased temperature to be owing to some specific action effected by the nerve when divided; but how produced he has not stated. Is it supposed that heat issues from the divided nerve? If so, the heat would be greatest at the divided part; but it is not so; the temperature of the limb is uniformly increased.

I do not intend to follow this force to the seat of volition or consciousness, or to enter upon the subject of paralysis; yet the remarks here presented seem to offer an explanation of some of the phenomena in lesions of the nerve-centres. I may be excused the suggestion, that when any of this force or energy is required in involuntary acts of the system—as, for instance, vaso-motor function, the action of the heart, etc.—the nerve-force is simply conveyed to the ganglia, and, without any change being effected there, returns by efferent nerve-fibre to these parts, to produce motor effects. From the free communication which takes place in ganglia and nerve-centres between the nerve-fibres and cells, we may readily understand how the "sympathy" of one part with another is effected through increase or decrease of current and conducting power of nerve. Dr. L. Seale thus speaks upon this subject; and, as his opinion closely approaches Dr. Richardson's and mine, a brief allusion will be given.

"It may now be nearly regarded as proven that the nerve-fibres do not terminate in the parts to which they are distributed, but, after travelling from some particular centre to an extremity, then take a backward course, and finally arrive at the point from which they started. Admitting this view, we then have another fact in support of the hypothesis that nerve-force, as it is called, is nothing more than electricity acting under peculiar conditions. Dr. Beale, though he by no means claims for this doctrine an universal assent, still conceives it to be at least probable. In speaking of the two sets of cells, *caudate* and *rounded*, which are connected with the nervous filaments, he attributes to the latter the power of originating currents, while the other is concerned more particularly with the distribution of these, and of secondary currents induced by them, in very many different directions. A current, originating in a *ganglion-cell*, would possibly give rise to many induced currents as it traversed a *caudate nerve-cell*. It seems probable that nerve-currents, emanating from the rounded ganglion-cells, may be constantly traversing the innumerable circuits in every part of the nervous system; and that nervous actions are due to a disturbance, perhaps a variation in the intensity of the currents, which must irremediably result from the slightest change occurring in any part of the nerve-fibre, as well as from any physical or chemical alteration taking place in the nerve-centres, or in any of the peripheral nervous organs."

How Dr. Beale accounts for the origin of nerve-force from the rounded ganglionic cells themselves, I cannot see. It cannot originate of itself; nor can the cells generate force; this alone must come from

something which has previously existed as motion or force in some form or other, and thus become appropriated through nerve-ganglia, cells, and fibre, for the requirements of the system. Dr. Richardson conceived the idea of the origin of the energies of the system from the oxidation of carbon, etc., acting upon nerve-fibre, wherever found. We agree together so far as the origination of nerve-energies in the capillaries by oxidation; and it is here our views differ. M. C. Bernard has given one experiment which proves that nerve-force is not generated at the peripheral extremity of sensitive nerves of the cerebro-spinal system, but rather that the nerves of this system receive their force or energy from the sympathetic nerve-cells at their periphery.

"Having opened the spinal canal in dogs, he divided, as they left the chord, all the origins of the sacro-lumbar plexus (sometimes on one side, and then the other), which supplies sensation and motion to the hinder extremity. The limb became completely paralysed, but no calorification or vascularisation was observed; the temperature on this side often, indeed, diminishing. When only the posterior and anterior roots were divided, corresponding abolition of sensation or of motion occurred; but in neither case were there any vascular or calorific effects in the limb. In a dog, in which complete paralysis of the left hind leg was produced by division of the origins of the sacro-lumbar plexus, the *sciatic nerve* (and thus the sympathetic) was afterwards divided. Vascular and calorific phenomena immediately followed; the temperature of the limb steadily rising until it was from 11° to 15° Fahr. higher than that of the opposite one, and so continued until the death of the animal the next day."

It is obvious from this experiment that, if nerve-force originated at the periphery of the nerves of the cerebro-spinal system, we should have "calorific" effects when these nerves are divided at their roots since the current to the centres would be arrested, and, instead of a nerve-current, increased heat would be generated in the limb, as occurs when the sympathetic is divided. Therefore we can readily understand how nerve-force generated by oxidation in the capillaries takes two courses; one—the chief—along the sympathetic nerve-fibre to ganglia, and thence to nerve-centres; the other through a connexion with ganglionic cells with the peripheral extremities of sensitive nerves—all nerves of sense—in such amount as is necessary to supply these with their special functions. It therefore follows that increased temperature of the limb in this experiment does not take place as where the sympathetic is divided; for the nerve-force, which is prevented passing along the divided sensitive nerve, will pass along the undivided sympathetic nerve-fibre, together with the rest.

It is not necessary to discuss the question whether nerve-energy is generated at the peripheral extremity of motor nerves, since these receive their energy from the nerve-centres. In addition to what I have stated in the *BRITISH MEDICAL JOURNAL* for February 4th, I beg to refer to three cases of embolism of the arteria centralis retinae, recorded in the *Ophthalmic Review*. At page 113, Dr. Liebreich says he has met with eight cases of this affection, and gives notes of an interesting case of loss of vision by this means. Two cases will be found at pages 163 and 196. The loss of vision comes on suddenly, and there accompanies them dilatation of the left ventricle, with diastolic *bruit*. Von Gräfe gave the first detailed account of these cases; and, a year and a half after the attack, the patient died; and, on a *post mortem* examination, the diagnosis was fully confirmed by finding occlusion of artery. The evidence afforded by these examples of suspended and de-

stroyed function of vision proves indisputably the immediate necessity of the arterial blood supplied to an organ for the performance of its functional activity, be it in the eye or any other part. Here we see blindness coming on; and, if we consider the loss of sensation in a limb when the main artery is ligatured, the two cases are seen to be strictly parallel in result; viz., loss of function or sensation. This effect is not the result of suspended nutrition of the nerve by cutting off the supply of its nutritive fluid, as is proved by the instantaneous effect. It is alone the suspended oxidation which supplies all organic, and, through these, sensitive nerves, at their periphery, with nerve-force. Thus, when heat, light, sound, or any mechanical stimulus, is received by an afferent nerve, force is necessary to convey it to the nervous centre.

Dr. Richardson denies, although I believe, that when "an impression is made upon the skin, eye, ear, etc., this is conveyed in a current to the brain;" he holds "that the impression disturbs the balance of nerve-fluid throughout its universality." Although the picture of an object falling upon the retina is not conveyed along the optic nerve, yet the excitant or stimulus—light—acts upon the different parts of nerve-expanse, and the impression of the picture made upon the retina is conveyed to the brain, and there produces the same pleasurable sensation—in fact, a picture or sensation of one in the brain, just as we perceive pictures in our dreams, of all colours and vividness, when the eyes are closed in sleep, and no impression upon the retina is received.

I have attempted to give an idea how all forces are correlated both in the animate and inanimate world; and the contemplation of the subject inspires one with wonder and reverence—with the simplicity and magnificence of creation. However inclined, the subject is too vast to dwell upon longer. We will endeavour to apply our knowledge of this subject to the phenomena of diseased action in the human system; and, however imperfectly this may be accomplished, my efforts may serve as indications for others more able to effect. As yet there is one matter which has not been alluded to, and which is concerned in the circulation of blood in the capillaries; viz., endosmosis, etc.

"In endosmosis, when one current exceeds the other, the difference is called the endosmotic equivalent; and what is observed out of the body, the same does take place within it. When, for instance, liquids are poured into the intestinal tube, and absorbed by its villousities, no exchange whatever is observed from the villousities, owing to the more rapid current in these. This difference between the phenomena which take place in living animals, and those observed in organic matter, is due to the rapid motion of the fluids contained in the absorbent vessels; the torrent of circulation carries off the liquids which bathe this outer surface, without restoring an equivalent, according to the ordinary laws of endosmosis, because, in the normal state, the flow of blood is continuous. But, if we arrest its progress by placing a ligature on the vessels, the results obtained are strictly similar to those obtained in the endosmometer; the exosmotic current is then produced as usual (albumen and the salts of the blood exude), the fluids being placed in a state of rest. If the motion of the blood be somewhat arrested, by obstruction from pressure or tumefaction (as in inflammation), the endosmotic action is modified, and effusion will take place. When it is accelerated locally, the absorption continues with still greater activity than before. The activity of this function entirely depends, therefore, upon the rate at which the blood passes through the capillaries."

The absorption of the nutritive fluids in the stomach and intestines, and of oxygen in the air-cells of the lungs, is produced chiefly by the motion and free current of blood through the capillaries of these parts. This is called the *endosmotic current*; and from this known fact of the action of fluids in motion, we may suppose the motion of blood along the capillaries and veins produces the absorption of most of the fluids in the body and extremities. We observe the opposite effect, however, when the current of blood in capillaries is greatly arrested; as in inflammations we have *exosmosis*, owing to the expanded state of the capillaries, and the *arrested* or *lessened* circulation through them. Hence we have solidification of lung in pneumonia, exudation of tough mucus in bronchitis, fibrinous membrane in croup, diarrhoea in enteritis, plastic fibrine in peritonitis and pleuritis, etc. These effusions are increased by too depressing treatment and abstinence from food, especially late on in the disease. M. Bernard has shown that, when the sympathetic in the neck is divided, and the animal well fed, all goes on well, except the increased heat and vascularisation; but, when it is poorly fed, purulent formations are the result in the parts supplied by the nerve on that side. M. Cl. Bernard says: "When the cervico-cephalic branch of the sympathetic has been cut, the conjunctiva, the pituitary membranes, and other mucous surfaces, enter at once into suppuration, when the animal is momentarily deprived of food; so, when the splanchnic nerves are divided, the internal organs of the chest and abdomen suffer in like manner." This result will be owing to weakened action of the heart and defective nutrition; hence diminished endosmosis of oxygen in the lungs from weakened blood-current; and, from the same cause, the formation and deposition of pus will be increased. In cases where this tendency was remote, under favourable conditions, as by lowering the heart's action or depressing treatment, this result would be fulfilled.

We will here consider the leading phenomena of inflammatory action. On what do the heat, redness, and swelling of inflammation depend? There can be no doubt that the organic nerve of a part inflamed has received some lesion, either by mechanical injury, or by depraved nutrition of the nerve affecting its conducting powers to and from its centre or ganglion. In fevers and idiopathic inflammations, it is very probable the whole of the organic system has been undergoing some changes prior to the advent of the disease or the unequivocal symptoms, and which being influenced by meteorological and other influences, the body has been prepared for any further cause which we are inclined to attribute as the sole cause of the disease. Here we perceive three conditions, which, by their presence or absence, preserve health or produce diseased action: 1. Healthy and well prepared material or blood; 2. Proper oxygenation (producing heat and nerve-force), and the due conducting or healthy condition of organic nerves; 3. The free and full action of the heart. The first of these general causes comprehends to some extent those causes which lead to defective nutrition of nerve; viz., good digestion of food, pure air and exercise, with buoyancy of spirit or mind. The effects are the same as occur when the sympathetic has been divided in the neck; viz., dilatation of the vessels, heat, excited sensibility, redness and effusion of various kinds, according to the part or organ affected. In the second condition, the transmission of nerve-force being stopped along the organic nerves, we have increased sensibility, partly owing to the excitant or irritant nature of effused products, but chiefly to the increased temperature of the part inflamed. It has before been shown that this

increased heat is wasted nerve-force, so to speak; or what ought and would be nerve-force, if the nerves possessed their healthy conducting quality. Hence the absence of vaso-motor power, and an expanded state of capillaries. The effusion which ensues in a superficial inflammation is analogous to that in all organs: the phenomena which are presented in all depend upon their peculiar functions, and their disturbance. The capillaries most pressed upon by the tumefaction pour out their contents, or exosmosis takes place; others of these, nearer the surface, will be more expanded than natural; hence absorption by the greater current of circulation through these capillaries, or endosmosis. These changes, progressing, lead to the absorption of tissues and the discharge of abscesses.

In passing, it may not be amiss to allude to alcohol. How does it act? It is apparent that saccharine, fatty, and probably alcoholic matters, produce nerve-force as well as heat; whilst albuminous matters supply the structures by which the body is moved—viz., the muscles and connective tissues. Alcohol may act in the *healthy body* upon the inner surface of the heart and capillaries and the nerves of sense as an excitant only, and the chief amount taken into the system be carried away without undergoing combustion; and thus, after serving this end only, will leave the system enfeebled to the extent to which it has called forth its powers. But what concerns the profession to know is, what are its effects in the enfeebled states of the body, or in low states of disease, as in typhoid fevers, etc. It will act here also as an excitant; but I am persuaded that it does more than this; that it is oxidised, since it does not intoxicate even when given in large quantities, but rouses up the energies of life. The mind resumes its wonted calmness and power, when properly administered, to a much greater extent than can be accounted for by its excitant effect; yet the excitant effect in these cases will be greatly diminished here, since the sensibility and power of the system are greatly reduced; hence the marked effect in these cases is from oxidation. And no smell of alcohol is perceived in the breath and urine of such. It would be desirable to examine the tissues of the body and brain where it has been largely given in these low states of body, to settle this vexed question.

M. Cl. Bernard has shown that, after section of the sympathetic nerve, the blood contains a larger amount of fibrine than usual, and is more easily coagulated, as in ordinary inflammation. This teaches us that, after the relief of congestion of a part or organ by local or general depletion, we may in many cases prevent the too great effusion of fibrine by the cautious use of alcohol; for it is evident that the oxidation of alcohol will, so far as it becomes oxidised, prevent the oxidation of albumen into fibrine; for that which will unite with alcohol would otherwise unite with albuminous matters. Again, alcohol will, according to Dr. L. Beale, produce an excitant or contracting effect upon the capillaries, and thus reduce effusions by keeping down tension. The good effects of alcohol, however, are seen in low cases of fever, and inflammations attending these, in which no fibrine is effused, and also where little of fibrine exists in the blood of these cases. Here we perceive the mind rouses up from lethargy; or, if rambling, it becomes calm and conscious; the pulse becomes full and steady; and a marked improvement takes place, from the heat and nerve-force which it is capable of giving to the system by oxidation. By its excitant action upon the heart, the blood will flow through the capillaries of the lungs with more vigour, and thus produce (by endosmotic current) a greater amount of

oxygen. It may not be amiss to point out the heat capable of being produced by the heart's action.

The amount of mechanical work performed by the heart has been computed by the Rev. Samuel Haughton, M.D., etc., to be equal to 124 foot-tons per day. A near approximation of this may be arrived at by considering the height to which the column of blood is sent from the aorta, and its weight. From the above, we may consider the left ventricle expends force equal to 100 foot-tons per day, at least. This, reduced to pounds, is 224,000 foot-pounds, which, divided by 772, the mechanical equivalent for heat (for 772 foot-pounds equal the amount of heat necessary to raise one pound of water 1° Fahr.), there will be produced about 289° as the quotient—an amount of heat which, divided by 145, the average weight in pounds of a man's body, will give the actual amount of heat which is capable of being produced by the arrest of mechanical force of 100 foot-tons per day; viz., 2° Fahr. for each pound of matter which constitutes the body. When we come to consider this amount divided over the space of twenty-four hours, we shall see how inappreciable this would be at any one of the twenty-four hours; for the heat generated by this means would be inapplicable to us. But we are not certain that all this force is converted into heat. Part is, no doubt, converted into frictional electricity, if we may use the term; owing to the heterogeneous nature of the blood and the coats of the vessels. Friction of homogeneous bodies produces heat alone; of heterogeneous bodies, heat and electricity.

The application of the facts here contained, and their relations in diseased actions, are almost universal. One symptom observable in mechanical injury of the spinal cord is great elevation of temperature in one or both of the lower extremities, owing to injury of the sympathetic, and the arrest of nerve-force to the centres; and hence the same effects as when this nerve is divided in experiments. As Dr. Brown-Séquard has lately said in a lecture, "the circulation in these cases is not more rapid, but fuller and (more energetic)?"), than in the corresponding limb. Hence the heated condition of the blood and limb could not be greater than in the other or healthy limb; for, although the arteries may be more expanded on the injured side, from the deficient power of vaso-motor nerves which cause contraction of these vessels, there cannot be more—probably less—of the heart's force arrested and converted into heat.

It will be evident that "determination of blood" to a locality or organ cannot exist, but that it depends upon lesion, disease, or malnutrition of the vaso-motor nerves, which allows the capillaries to become congested and inflammation to result. The importance of this question and of allied conditions known to exist in the phthisical constitution, will enable us to understand the deposition of tubercle in the lungs, etc., and heat in the axillary region.

NOTES ON HERNIA.

By JOHN THOMPSON, M.D., F.R.C.S., Bideford.

[Concluded from page 371.]

THE necessity for care in the after-treatment of cases of herniotomy is amply shown by clinical observation. After bringing the edges of the wound together, and retaining them in apposition by sutures and plaster, a difficulty may arise in keeping the intestine quietly reduced. Where a hernia has had for its immediate cause some violent but temporary muscular effort, the call for which passed at the time, there will be no further unnatural compression of the