CONTRIBUTIONS
TO THE
PATHOLOGY OF THE SPINAL CORD.

BY WILLIAM BUDD, M.D.

COMMUNICATED BY JOHN G. PERRY, Esq.

READ MARCH 26TH, 1839.

THE functions of the spinal cord have, of late, much engaged the attention of physiologists, and have been studied with great success by Marshall Hall, Müller, Volckmann, and others. The leading fact, which their investigations have developed, may be thus briefly stated:—When the connection of the spinal marrow of an animal with the brain is severed by decapitation, or otherwise, and a stimulus is applied to the surface of the body, the influence of that stimulus is transmitted to the spinal marrow, and, being thence reflected to motor nerves, causes contraction of various muscles. In the experiments which show the different steps of this process, it is certain that the agency of sensation and volition is excluded. The part which the spinal marrow takes in the action has suggested the term reflex function. It has been further shown, that the brain has a re-

flecting power of the same kind : that the muscular contractions excited in this way, are, in all cases, independent of volition ; but that, in reflex operations of the brain, sensation is probably concerned.

I shall not stop to inquire into the originality of the recent investigations on this subject : it will be allowed by every one that the physiologists above named have made many and important additions to the facts established by former inquirers, and have, with a precision not attained by these, assigned to the functions of the spinal cord their real domain in physiology and pathology : and in whichever of these aspects we regard the subject, we are unavoidably led to acknowledge the interest and importance it owes to the valuable researches of Dr. Hall.

The investigations of physiologists have consisted chiefly in experiments on the lower animals : it is the object of this paper to show that, under certain circumstances, the operation of the reflex function is exhibited in man, in the same way as in decapitated animals. This I shall do by a series of cases of affection of the spinal marrow : as in these cases the inquiries are instituted on rational beings of our own species, they offer peculiar advantages for the study of some of the conditions of the reflex function.

CASE I.

John Lang, aged 43, and of temperate habits, without known cause gradually became crooked in

the back, and paraplegic, at the age of 18; but regained perfect use of his limbs at the end of two years. The paralysis returned twice; first after an interval of twelve years, and again after two more: each time it followed protracted exertion, but did not continue longer than a few weeks. It returned for the fourth time, and had continued fifteen months, when I first saw him. The curvature of the spine had not increased since the first illness, and in the intervals mentioned the health was quite good. There never had been, nor was there subsequently, any indication of abscess. In the first three attacks sensation was nearly extinct in the palsied limbs, but they had never exhibited involuntary movements. I saw him first in July 1836; and between that time and April 1837, visited him many times, and took the following notes of his case.

There is a projection in his back, without lateral deviation, forming a vast abrupt tumour, and comprising the dorsal vertebræ from the fifth to the eleventh inclusive: the spinous processes of all these are very prominent. The tumour is somewhat tender on pressure, but not otherwise painful.

Sensation in the lower half of the body begins to fail at the umbilicus, and is very much impaired immediately below it: in the lower extremities it is nearly extinguished; when these are smartly pinched, the patient perceives the nature of the act, but the sensation is very feeble. Has no power of voluntary motion over his lower extremities; once or twice, while he was making strong efforts of the will,

I observed a very limited motion of the great and second toes ; but had I not watched very narrowly, these movements would have escaped my notice : after having occurred once, or at most twice, he could not repeat them.

These are the only voluntary movements of the lower extremities which the patient can execute. When, however, any part of the skin is pinched or pricked, the limb that is thus acted upon jumps with great vivacity : the toes are retracted towards the instep, the foot is raised on the heel, and the knee flexed so as to raise it off the bed : the limb is maintained in this state of tension for several seconds after withdrawal of the stimulus, and then becomes suddenly relaxed. Once or twice, while the left leg was thus excited, the great and second toes of the right foot were simultaneously drawn towards the sole : the converse never occurred, and, in general, while one leg was convulsed, its fellow remained quiet, unless stimulus was applied to both at once. The contractions excited by stimulating the left leg are uniformly more vigorous than those excited in the right by a like stimulus. In these instances, the pricking or pinching was perceived by the patient ; but much more violent contractions are excited by a stimulus of whose application he is perfectly unconscious.

When a feather is passed lightly over the skin in the hollow of the instep, as if to tickle, convulsions occur in the corresponding limb much more vigorous than those induced by pinching or pricking ;

they succeed one another in a rapid series of jerks, which are repeated as long as the stimulus is maintained. In these experiments the patient is quite unconscious of any thing touching his limb. When asked if he feels any thing, his invariable reply is, "No, I feel nothing, but you see my leg feels well enough." When any other part of the limb is irritated in the same way, the convulsions which ensue are very feeble, and much less powerful than those induced by pinching or pricking. No movements are excited in his lower extremities by tickling any point in the upper half of his body, though such tickling occasion laughter.

Convulsions, identical with those already described, are at all times excited by the acts of defecation and micturition. At these times the convulsions are much more vigorous than under any other circumstances, insomuch that the patient has been obliged to resort to mechanical means to secure his person while engaged in these acts. To this end two large loops of saddlers' webbing are nailed to the floor; into these the feet are inserted; while two longer loops, also nailed to the floor, are adjusted over the knees as soon as the patient is placed on the night-stool: an attendant is also required to hold down the thighs. During the act of expulsion the convulsions succeed one another rapidly, the urine is discharged in interrupted jets, and the passage of the fæces suffers a like interruption. The convulsions become more feeble towards the completion of the act, and the stream of urine becomes

continuous. In the case of making water, the convulsions are uniformly more vigorous the more the bladder is distended. When sufficient precautions had not been taken to secure his person, it had occurred to the patient to be thrown violently forwards on the floor. The passage of urine is felt by the patient, but the sensation is of a smarting kind. Slight involuntary contractions occur in the legs whenever the bladder is distended, and also when the desire to relieve the rectum is manifested. In all these circumstances, the convulsions are perfectly involuntary, and he is unable, by any effort of the will, to control or moderate them. The passions have no power of exciting convulsions. After the lower extremities have been much excited, a sense of tingling in them is experienced. Motility and sensation in the upper half are unimpaired, and quite natural. Appetite and digestion pretty good ; loss of flesh inconsiderable, and not progressive ; nutrition of the legs good.

Lang continued nearly in the same state until the spring of 1837, when, without any remedial means, he regained voluntary power in his lower extremities. and sensation also began to increase. These functions gradually improved ; and as voluntary power increased, the susceptibility to involuntary movements, and the extent and power of these, diminished. When I last saw him he was able to walk a little on crutches, and sit up many hours ; but he was still obliged to secure his legs when his bowels were moved.

At the period when the paralysis was the most complete, there was some difficulty of breathing and palpitation; and both these symptoms were always increased when the patient fell asleep, so that he was soon awakened by the distress they occasioned.

The interest of this case lies in the coincidence of these two circumstances:—total loss of voluntary power in the lower extremities,—involuntary muscular contractions, excited by application of stimulus to the skin or mucous membranes. There can be no doubt that these contractions were of the same nature, and excited by the same process as those observed in a decapitated animal. Although sensation was never quite extinct in Lang's lower extremities, it was evidently not concerned in the production of the involuntary contractions; for when an artificial mode of stimulus was employed, the convulsions were uniformly the most vigorous in that case in which the application of it was not felt by the patient, namely, when the hollow of the foot was lightly touched with a feather. Here then we have oral evidence from the subject of experiment, that these acts are quite independent of sensation and volition. The fact that such vigorous convulsions were excited by touching the hollow of the foot with a feather, is of great interest, and tends to show that the nerves which transmit these impressions to the spinal marrow are,—if not the same with those of true sensation,—most actively excited by a stimulus which produces strong impressions on

the sensitive nerves. Every one knows how urgent is the sensation of tickling in the hollow of the foot. Volkmann has proved that these two kinds of nerves (if there be two kinds) arrive at the spinal marrow in one bundle, namely, the posterior roots. That their distribution should be alike, is obvious, for their purpose is the same,—the reception of external impressions.

We must not fail to remark, that in the case of Lang convulsions were never induced by excitement of the passions.

Although paralysis lasted nearly two years, the lower extremities continued stout and muscular. This is interesting, because it has been found to occur in other cases of the same kind. In paraplegia, with entire loss of motility, the palsied limbs usually waste in a remarkable manner.

CASE II.

A young lady, of scrofulous habit, after having been affected with caries of the cervical vertebræ, and symptomatic abscess in the pharynx, for about two years, became paralyzed in the arms, at first exclusively, but in a short time afterwards in the right leg also. When I saw her, paralysis of the arms was complete as regards motility; sensation was much impaired, but not extinct. The leg was palsied only in regard to voluntary motion, and exhibited involuntary contractions under the same circumstances as in Lang's case. They were, however,

more readily excited: the slightest disturbance of the bed-clothes in contact with that limb excited a very energetic contraction, throwing the limb into the same attitude as that described in the former case. After the contraction had lasted a few seconds, the muscles suddenly became relaxed, and the limb fell to the horizontal position. On each renewal of the stimulus, the contraction which ensued was much less vigorous than the previous one. The convulsions excited by defecation and micturition were much more powerful than those induced by any other cause. Twice during these acts the right arm had been convulsed in the same way as the leg, but in a much more feeble degree. Sensation in the right leg not much impaired. No convulsions ever remarked in the left arm or leg. The right leg was convulsed whenever the bladder was distended. Under all circumstances, the convulsions of the right leg were attended with pain, which was described as identical with that of cramp.

Dejections voluntary: sensation and volition were unimpaired in all parts except those before mentioned. Intellect and memory were not impaired.

This young lady was gradually wasted with hectic, and died with symptoms of suffocation. I could not obtain permission to open her body.

The successive diminution in the vigour of the contractions on each renewal of the stimulus, shows that the reflex motor power, like voluntary power, is liable to exhaustion. This is the only case I have seen in which the convulsions caused pain.

CASE III.

Robert Holland, a sailor, aged 17, of florid complexion, and robust growth: healthy until his present illness. In August 1837, received a severe blow on his back from the boom of his ship, which did not, however, disable him; he continued his work as usual. From that time suffered occasional pain of the loins and weakness in the back, especially when stooping. This continued without other complaint until the beginning of December, when he began to experience difficulty in running, and a sensation, when he attempted to run, as if his legs were tied; he could still climb the rigging, and continued his usual work throughout that month. The 1st of January 1838, he was obliged to desist, on account of increased impediment to the movements of his legs. From the 1st to the 4th he was still able to walk, though with much difficulty; when he attempted to stoop he fell on his knees, and could not rise again without the help of his hands. No weakness of the arms; up to that time there had been no involuntary movements of the legs. On the 4th of January was confined to bed on account of inability to stand, or to move his lower extremities. On the 8th of January he was admitted to the Seamen's Hospital; on admission, his lower extremities were observed to be in extension and very rigid, with sensation unimpaired, except slight numbness of the thighs. There was, for a few days after admission, difficulty of making water,

which was passed with much straining. The tetanic condition of the lower extremities continued ; and in the interval between admission and the 11th of March 1838, the state of the patient was as follows :—

Sensation in the lower extremities unimpaired ; voluntary motion abolished in these limbs, which are rigid, from permanent contraction of the muscles. The legs are sometimes extended, sometimes bent upon the thigh, and the transition from one condition to the other is quite involuntary. When these limbs are in extension it requires great force to bend them in the slightest degree ; and when that force is withheld, they immediately return to their former position ; the converse holds when the legs are flexed. When any part of the skin of the lower extremities is pinched, the corresponding limb jumps with great vivacity ; if previously in extension, it momentarily assumes a state of flexion, and *vice versa*. Occasionally, when one leg is thus excited, its fellow is, at the same time, similarly affected, but not so powerfully. The muscular contraction thus excited is very powerful ; it is quite involuntary, and cannot be modified in any way by influence of the will. When any other part of the body is pinched no analogous movements are induced ; but when the patient voids his urine, both legs are always affected in the same way as by pinching their integument. When the legs have been much stimulated by pinching, they become affected with a quivering motion, which lasts some minutes : this also occurs after micturition ; no pain whatever in the legs, nor sense

of fatigue ; calves stout and developed ; dejections voluntary. There is curvature of the spine, formed by prominence of the dorsal vertebræ, from the fourth to the ninth, inclusive. Motility and sensation perfectly natural in all parts of the body, other than the lower extremities. General health not much impaired. Soon after this the legs became less rigid, and on the 24th of March were observed to be quite placid ; convulsive movements could still be excited, by pinching or tickling, but were much more feeble than before.

In the beginning of April profuse hæmoptysis took place, and was soon followed by other symptoms of phthisis ; large sloughs formed on the sacrum and hips ; he wasted rapidly, and died much emaciated, on the 3rd of May. His intellect had continued unimpaired ; the lower extremities quite deprived of voluntary power, but with sensation unaffected ; and slight convulsions in the legs could be excited to the last.

On examination, after death, the curvature of the back was found to be formed by prominence of the dorsal vertebræ, from the 5th to the 9th, inclusive, the 7th being the most prominent.

On dividing the vertebræ, the laminæ of those corresponding to the curvature were found somewhat softened, especially on the right side. As soon as they were divided, a small quantity of yellow pus oozed from the right side of the spinal marrow, exterior to the dura mater. The dura mater, for the space of an inch and half, corresponding to the most

projecting portion of the spine, had a dark, greyish, stain, externally, and was much more vascular than the portions above or below the curvature, which were pale and quite natural in appearance. Below the curvature, however, the dura mater was distended by transparent serous fluid. The diameter of the cord was considerably smaller in the portion corresponding to the curvature, than in any other part throughout its whole length. The cord was removed contained in the dura mater, and the latter laid open in its posterior aspect. There was no pus in the sheath. The vessels of the pia mater were very tortuous, and much congested with florid blood in the parts above and below the curvature, but more so below, and less in the part corresponding to the curvature, than either above or below it. No change whatever in the appearance of the arachnoid, or of the inner surface of the dura mater.

The cord itself was of natural size ; and a portion, about two inches in length, corresponding to the curvature, softened in the posterior columns. The tissue was not diffluent, but became flaky and partially dissolved, when a small and gentle current of water was poured on it. This did not happen when a like current was similarly directed on other portions of the cord. This breaking down of the tissue was much more marked in the posterior than in the anterior columns, which were scarcely, if at all, softened, and resisted considerable traction. After the arachnoid had been removed, the posterior columns had still sufficient consistence to retain their form.

The affected portion was quite white, exhibiting no vascularity or bloody points. The nerves within the vertebral sheath, arising from the softened part, were firm, and of natural appearance. The cord, above and below, perfectly healthy, firm, and of good colour. When the contents of the chest were removed, an abscess was found, surrounding the bodies of the diseased vertebræ, its anterior wall being formed by the aponeurosis of the vertebræ. The abscess contained yellow, inodorous, grumous pus.

Both lungs offered grey granulations, and some tubercles, partially softened. The right lung was in a state of hepatisation.

REMARKS.

The absence of any feeling of fatigue in the lower extremities, after such a long period of muscular action, is very remarkable, and seems to show that fatigue is associated with the exercise of voluntary actions only. It is not felt in the sphincters. It is also worthy of remark, that the sensibility of the legs was unimpaired, although the posterior columns of the spinal cord were chiefly affected.

Extensive reflex actions, like those described in the preceding cases, are the most striking symptoms of apoplexy of the pons varolii. In an admirable article on apoplexy, in the “*Dictionnaire de médecine et de chirurgie pratiques*,” M. Cruveilhier quotes from Ollivier the following instructive case :—

“A man, at work in the fields, complains all at once of acute pain and buzzing in his ears. He immediately runs off, as if to escape from threatened danger. He drops, and there is loss of consciousness; frequent, irregular, and noisy breathing; sometimes stertorous. He sneezes twice with violence; there is stiffness and convulsions of the limbs, alternating with a state of collapse; froth at the mouth, and an epileptiform condition. He dies at the end of five hours, and was not observed the last two. It was not determined whether or not sensation was abolished, but a convulsive movement of the right arm was observed when the skin of that limb was pinched, and a similar movement at the moment when the integuments were pierced in venesection.”

M. Cruveilhier justly remarks, that these movements were no indication of sensation; and states, that he has often seen them independent of volition in paraplegia. This interpretation of the fact is, undoubtedly, the true one, and the convulsions in question were acts of the reflex function.

On examination after death, the pons varolii was found converted into a sac, full of blood, in part coagulated. The blood had found its way to the surface of the pons by a small lateral opening, and also into the fourth ventricle, which was distended with it.

M. Ollivier states, that he has since seen many examples of apoplexy of the pons, at the moment of

attack, and has always remarked convulsions of the extremities.

Since the account of the preceding cases has been in the hands of the secretary, my friend, Mr. Busk, has kindly furnished me with the details of all the cases of paraplegia from injury to the spine that have been received into the Seamen's Hospital, Dreadnought, during the last year. Some of these were attended with circumstances of uncommon interest, and were observed with great care. I shall therefore give a narrative of them as succinctly as I can without suppression of important circumstances.

CASE.

Thomas Colborne, aged twenty-six, was received into the Dreadnought the 14th September 1838, the day after he had fallen eleven feet into the hold of a vessel. He was rendered insensible for about twenty minutes by the fall, and did not know on what part of the body he alighted. On admission to the hospital the following circumstances were taken note of:—A puffy crepitant swelling about the last cervical vertebræ, with extreme tenderness, and acute pain on the slightest motion of the neck; total loss of voluntary power in the lower extremities, trunk, and hands; slight remaining voluntary power in the wrists; rather more in the elbows, and still more in the shoulders; less in the left arm than in the right. Fingers flexed; breathing abdominal; sensation much impaired in the hands and feet, especially in the lat-

ter; painful burning sensation in the back of the hands, without morbid appearance; erection and frequent motion of the penis; retention of urine; involuntary stools; intellect unimpaired; countenance natural; slight involuntary movements in the feet when the soles were tickled.

This man is still in the hospital (March 6th 1839), and in progress of recovery. The following is a succinct narrative of his case:—There was no return of voluntary power in the palsied parts until the 30th day after the accident, when Colborne was first able to move his right thumb a little, the fingers of the right hand, at the same time, feeling less stiff than previously. On the 39th day he was able to move these fingers freely, and also had voluntary power over the recti abdominis.

On the 69th day he regained some voluntary power in the lower extremities; could move the right foot and leg, and left great toe; and, on the 70th, could raise his heels several inches from the bed; but there had been no further increase of power in the hands and arms. There was little change, as regards voluntary power, from this time to the 95th day, when he was first able to stand with support, and enjoyed increased power in the hands. On the 101st day he could stand without support, and walk a short distance. On the 121st there was much increase of voluntary power; and, on the 141st, Colborne was able to walk about, resting his hands on the back of a chair, which he pushed before him. On the 30th day he first be-

came conscious of desire to pass urine and fæces ; but the evacuations continued involuntary notwithstanding, being effected forcibly immediately after the desire was felt. On the 141st day he regained some control over evacuations from the bowels ; and, on the 151st, they were quite voluntary ; but the discharge of urine continues involuntary to this time.

During the period comprised in these observations, involuntary movements of the palsied parts could be easily excited. For the first seven days they were limited to slight movements of the feet, excited by tickling the soles, and could not always be induced. On the 9th day the movements excited in this way were much more powerful than before, and, from this to the 26th day, rapidly increased in power and extent, in the following order of progress :—At first, tickling one sole excited to movement that limb only which was acted upon ; afterwards, tickling either sole excited both legs ; and, on the 26th day, not only the lower extremities, but the trunk and upper extremities also. Tickling the left sole, where the cutis was denuded by a slight vesication, excited much more powerful and extensive convulsions than tickling the right sole ; the convulsions excited by acting on the right sole being a constant tremulous motion. The convulsions in the right arm were always more powerful than in the left, where at first they could not be excited at all, and were, throughout, very feeble. Irritating the soles, by tickling or otherwise, was at first the only,

and always the most efficient method, by which convulsions could be excited. From the 26th to the 69th day, involuntary movements in all the palsied parts continued powerful and extensive, and were excited by the following causes :—In the lower extremities only, by the passage of flatus from the bowels, or by the contact of a cold urinal with the penis ; convulsions in the upper extremities and trunk, attended with sighing, by plucking the hair of the pubes. On the 41st day a hot plate of metal was applied to the soles, and found a more powerful exciter of movement than any before tried. The movements continued as long as the hot plate was kept applied ; but the same plate, at common temperature, excited no movements after first contact. The contact was distinctly felt by the patient, but no sensation of heat was perceived by him, although the plate was applied hot enough to cause vesication. Ice applied to the soles was also tried, but did not excite more powerful or more general convulsions than a body at common temperature ; the ice did not cause any sensation of cold to the patient. Pricking the legs, or pulling their hairs, had a like effect to that of tickling the soles. Introduction of the catheter excited convulsions in the trunk and limbs, and convulsions also occurred during and preceding evacuation of the bowels ; such evacuation being involuntary, but attended with consciousness of the act.

There were also frequent spontaneous twitches, unattended with pain, commencing in the heels, and

affecting the legs and arms, and the muscles of the trunk, as high as the ribs; violent spontaneous movements frequently followed long-continued efforts towards voluntary motion. At three different intervals Colborne took, for some days, one-eighth of a grain of strychnia three times a day. Great increase of susceptibility to involuntary movements immediately followed, and they were excited by the slightest causes: by sudden noise; by the passage of persons near the bed, or by the slightest touch of the coverlids; by blowing on the legs, and by various other slight impressions. Pulling the hair of the head excited strong convulsions in the arms, and tickling under the chin still more powerful ones. No convulsions in the upper extremities could ever be excited by irritating their integument. Spontaneous convulsions of the palsied parts were also more frequent and more powerful after the use of strychnia, and, for one day, the knees were observed in tonic flexion. On the 43rd day it was observed that, after the right fore finger had been excited to involuntary movement for about half a minute, it became transiently endowed with voluntary power, being, under all other circumstances, cut off from volition. The involuntary action of that finger was always greater than of any other.

It has been already stated, that the discharge of urine was involuntary, although the patient early felt desire to void it. At first the urine dribbled away almost constantly; but considerable quantity could, notwithstanding, be drawn off by the cathe-

ter. After the 95th day it was passed involuntarily, and with a sort of jerk, about every two hours. Up to the 62nd day priapism was generally present : it appeared to depend in great measure on the quantity of urine in the bladder ; and if present before catheterism, it generally subsided immediately after. Once or twice it seemed to be excited by tickling the soles. On the first return of voluntary power, the patient was enabled to restrain, in some measure, the excited movements ; but this required a distinct effort of the will, and the first attempts to walk were curiously affected by persistence of the susceptibility to excited involuntary movements. When he first attempted to stand, the knees immediately became forcibly bent under him : this action of the legs being excited by contact of the soles with the ground. On the 95th day this effect did not take place until the patient had made a few steps ; the legs then tended to bend up, a movement which he counteracted by rubbing the surface of the belly : this rubbing excited the extensors to action, and the legs became extended with a jerk. A few more steps were then made ; the manœuvre repeated, and so on. This susceptibility to involuntary movements from impressions on the soles gradually diminished ; and, on the 141st day, as before stated, Colborne was able to walk about, supporting himself on the back of a chair which he pushed before him ; but his gait was unsteady, and much resembled that of chorea. Sensation improved very slowly. On the 53rd day he could first slightly perceive the heat of

the metal plate ; but the sense of contact was present long previously, although, up to the 121st day, there was much numbness in the soles, especially in the fore part. Sensation in the hands returned earlier, and was quite restored on the 121st day in all the fingers except in the little finger and ulnar side of the ring finger of each hand.

The general symptoms were at no time very alarming. There was some degree of fever for the first three weeks. On the 6th and 7th days, slight, transient delirium ; but in the intervals the patient appeared happy, frequently laughing aloud. The pulse, on admission, was small, and only 48 : it afterwards ranged from 60 to 72, and once was 84. On the 34th day it was observed that the pulse was 72, and regular, when the patient was recumbent ; 92, small and irregular, when he was erect.

Breathing was difficult, and wholly abdominal, for more than a month.

The 26th day there was great improvement in general health. The appetite was good. This improvement suffered no interruption ; and, on the 101st day, the patient had become quite fat, and his general health excellent.

The urine was observed to be alkaline, bloody, and charged with ropy mucus on the 3rd day ; and, for nearly 60 days afterwards, it was generally ammoniacal, and often contained much ropy mucus ; sometimes pus and clots of blood.

For some time after Colborne had sufficiently re-

covered to walk with crutches, violent spontaneous convulsions came on every night soon after he had gone to bed. These convulsions were prevented, or, if present, immediately quieted by giving him three or four drops of hydrocyanic acid, or twenty-five drops of tincture of digitalis.

This very important case suggests a long train of reflections. The convulsions of the palsied parts were clearly of the same nature as those observed in the preceding cases. Their independence of sensation was curiously shown by the difference of effect from the application of a heated plate, and of the same plate at common temperature, although the difference of heat in the two cases was not felt by the patient, the sense of contact being all that was perceived. This continuance of the sense of contact, while that of temperature was completely lost, is a novel and interesting illustration of the speciality of sensations ; a subject so ably treated by Sir C. Bell.

The great power of heat, as an excitor of involuntary movements, is also a fact* of intrinsic interest. Not less interesting was the circumstance, that convulsions could be readily excited by impressions on surfaces above the seat of injury ; as, by pulling the hair of the scalp, by sudden noise, and so on. This is proof of two important points : first, that a lesion of the cord may be such as to intercept the transmission of voluntary influence, and yet allow the transmission of that reflected from incident nerves.

* This was first observed by Mr. Grainger.

Secondly, that all influences from impressions on incident nerves, are diffused through the cord ; for, in the instance adduced, the reflected influence was undoubtedly not deviated into the cord by the morbid condition of that organ, but followed its natural course of diffusion, being rendered manifest in this case by the convulsions which were excited in consequence of increased activity of the motor function of the cord ; it must be borne in mind, that the diffusion of this influence took place, not in its course towards the cerebrum, but downwards through the cord. The fact is of great interest in physiology, and fertile in applications to the study and treatment of disease. It was long ago distinctly stated by Broussais, and in relation to the phenomena of mind, was developed with singular ability by that celebrated physician.*

The dependence of priapism on distension of the bladder, (if real) in this case, shows that impressions on incident nerves may be reflected so as to cause organic processes, in the same manner as to excite muscular contraction.† The connection of this with the subject of sympathies is as interesting as it is obvious.

The periodic discharge of urine in Colborne's case, seems to show that distension is the chief mode of excitement to reflected movements, in cavities with a muscular coat. The inability to excite convulsions

* *Traité de la Physiologie appliquée à la Pathologie.* 1823-24.

† The reader is referred to Müller's *Physiology* for proof, that erection is caused solely by vascular turgescence.

in the upper extremities, by irritating their integument, must have been owing to some lesion of the incident fibres of their nerves, as convulsions were readily excited in the arms, by impressions on other surfaces. The superior activity of effect from impressions on the soles, in this and other cases, is interesting on account of its generality. The limitation to the palsied parts of convulsions excited by the use of strychnia is quite general.

It is important to remark, that but very slight convulsions could be excited immediately after the accident, and that they gradually increased in extent and power.

The fact, distinctly observed, that one of the fingers became transiently endowed with voluntary power, after it had been some time excited to involuntary action, although difficult to interpret in the present state of science, is likely to acquire importance as our knowledge of this subject advances.

The ropy matter observed in the urine, was probably not mucus, but pus, altered by the action of ammonia. From a comparison of this case with the following, and with some others I possess, I am inclined to question the correctness of the theory which ascribes the alkalinity of the urine to an alteration in the function of the kidney, caused by deficient or altered innervation. I rather believe it to be the consequence of retention of the urine, in presence of the morbid secretions of an inflamed bladder.

CASE.

Adolphe Brandt, aged 43, was received into the Dreadnought three hours after having fallen into the hold of his ship ; a fall of twenty feet. On admission the following circumstances were noticed :—a trifling scalp wound on the back of the head ; contusion of the right ankle ; considerable projection of the spine, above the tenth dorsal vertebræ ; total loss of motility in the lower extremities ; sensibility exalted in the integument of the flanks ; natural in the thighs ; diminished in the legs, and there attended with pricking and tingling. Penis, semi-erect.

In the evening of the third day from the accident, the lower extremities, for the first time, became susceptible of excited movements. By tickling the soles the whole of the left limb, but only the toes of the right, were excited to brisk involuntary movements. The patient was unconscious of these movements, otherwise than by sight. This continued without change, until the 9th day, when it was observed that the movements were limited to the toes in both feet, and that, after being produced a few times, they could not be further excited without considerable interval of rest. From the 9th day they gradually diminished in force and extent : could not be excited in the right limb after the 16th day, nor in the left after the 22nd. Voluntary power increased, exactly as the susceptibility to excited involuntary move-

ments diminished. The first return of voluntary power observed, was on the 9th ; it was very trifling, and confined to the muscles of the hips and thighs. On the 12th there was transient voluntary power in the right foot ; on the 22nd power to move the toes of both feet. Voluntary power increased rapidly from the 22nd, and, on the 29th, Brandt was able to sit up half an hour.

Expulsion of urine was involuntary to the 5th day ; afterwards, quite voluntary ; but the stools were passed unconsciously until the 18th day.

The urine was ammoniacal, for the first time, on the 8th day ; on the 12th it was very much so, and loaded with muco-purulent fluid, continuing so to the 16th, from which time it became less alkaline, and after the 23rd was quite natural and clear.

The sensibility of the integument of the flanks, and lower part of the belly, continued exalted to the 22nd ; that of the legs perverted still longer. On the 2nd day the pulse was 84, but afterwards increased in frequency, and continued at 100, or 108, up to the 9th day. There was profuse diarrhœa from the 5th to the 14th day, and much emaciation ; the muscles of the legs and thighs much wasted, soft and flaccid.

From the 15th day Brandt improved much in general health, and on the 55th day his health was considered quite good, but as voluntary power in the lower extremities was still feeble, one-eighth of a grain of strychnia, three times a-day, was ordered. Spontaneous convulsions ensued, generally coming on at

night, when the patient was on the point of sleeping. They affected the thighs chiefly, beginning in them, and passing up the muscles of the trunk towards the chest. After this Brandt rapidly gained strength in the lower extremities, and on the 115th day, when he left the hospital, he was able to walk without support, but stooped much, and had a marked angular projection at the lower part of the spine. His urine, though in appearance natural, became ammoniacal soon after it was voided. It was passed without difficulty, and there was no incontinence.

Many of the remarks I have made on the former cases, apply so obviously and so exactly to this one, that I think it unnecessary to repeat them. It is important to remark, that no involuntary movements could be excited for the first three days after the accident.

John Bennett, aged 47, on the 1st of December 1838, fell about six feet, into the bottom of a barge, and was stunned for a short time. He did not know on what part he alighted, but it was said to be his head ; was brought to the Dreadnought immediately after the fall. About half an hour after admission the following circumstances were observed. No mark of injury on the person, except a slight bruise on the patella ; no pain, except in the back of the neck, where there was much tenderness on pressure on the spinous process of the 5th cervical vertebra ; no pain of head. Pupils natural ; and senses, except that of touch, unimpaired. Was able to move the head slightly from side to side. In the upper extremities

all voluntary power lost, except very slight in the shoulders. Total loss of voluntary power in the trunk and lower extremities. Breathing abdominal, priapism present, and continuing after the use of the catheter. Sensation much impaired below a line level with the mammæ, but sufficient remained in the lower extremities to distinguish when any part of the feet or toes was touched ; but the sensation communicated was that of pricking : sensation, not less impaired in the hands ; more so in the left than in the right : could distinguish each finger of the latter, but not of the former.

Tickling the soles excited slight contractions of the extensors of the leg and toes, confined to the muscles of the limb acted upon ; more extensive in the right than in the left leg. This susceptibility was soon exhausted, and required rest for its recovery. A hot plate, though sufficiently hot to cause vesication, did not excite more powerful or more extensive movements than the same plate at common temperature. A slight sensation of warmth was perceived ; pulse 48 ; inspirations 13 ; calm and without rattle. When first admitted, sensation was completely abolished in the palsied parts, and no involuntary movements could be excited.

This man died seven days after the accident, and in the interval the following variation in the symptoms above described, was observed.

On the 4th day the involuntary excited movements had somewhat increased in power. On the morning of the 5th day sensation was nearly extinct

below the umbilicus ; when touched on any point, the sensation was referred to some other ; for example, when the sole of the left foot was touched, the sensation was referred to the right knee or some other part. There was no trace of involuntary movements. Priapism absent ; bladder kept itself empty, or nearly so. In the evening there was slight sensation in the inside of the leg, and in the sole of the right foot, and when the hollow of that sole was rubbed, or the hot metal applied to it, one slight convulsion was excited, which could not be repeated until after an interval of rest. A slight sensation of warmth was perceived when the hot plate was applied. Sensation quite extinct in the left lower extremity, and no susceptibility of excited movements.

On the 6th day sensation was extinct in the fore arm and hand ; slight in the upper arm ; slight in the trunk, from the mammæ to the lower edge of the ribs ; slight sensation in the inside of the right thigh, and in the sole of the right foot, but quite extinct elsewhere in the lower extremities. Irritating the right sole excited one feeble convulsion in the right thigh and leg ; irritating the left sole had no effect. There was no priapism, nor was it induced by catheterism, although this operation was felt by the patient. Cold water injected into the bladder was rejected with force. Stools involuntary ; sphincter ani moderately contracted. On the 7th day sensibility was completely extinct below the umbilicus, and involuntary movements could not

afterwards be excited. No involuntary movements could ever be excited in the upper extremities, by tickling the hands or otherwise.

The intellect continued unimpaired until the 7th day, when there was some wandering, the patient being rational, however, when roused. The pulse was then 84, breathing 28, without rattle. In the evening he became comatose, with stertorous breathing and contracted pupils, and at 8 P.M. he died.

The urine was slightly alkaline on the 4th day only.

Examination of the body, 15 hours after death :

Body rigid and in excellent nutrition.

Spine. Slight ecchymosis of the deep muscles on the posterior and anterior aspects of the cervical vertebræ. Bodies of the 4th and 5th cervical vertebræ broken transversely; left side of the arch of the 4th vertebra fractured, and the articular ligaments between it and the 5th lacerated. Arch of the 3rd vertebra broken on both sides. The ligamentum subflavum, between the arches of the 4th and 5th vertebræ, nearly detached from the latter; dura mater of the cord uninjured; the cellular tissue external to it, slightly reddened, from infiltration with blood. On dividing the dura mater longitudinally on its posterior aspect, the surfaces of the arachnoid were found adhering by numerous very slender filaments, but there was no vascularity nor opacity of the latter membrane. The vessels of the pia mater were full, but that membrane was in its natural state, and, as well as the arachnoid, free from

laceration. Externally, the cord exhibited no visible lesion, except a small reddish spot anteriorly, opposite the 4th vertebra, giving an indistinct appearance of ecchymosis ; but, in a small space opposite the same vertebra, the cord felt very soft, and on being divided longitudinally from the posterior aspect, its interior was found converted into a red semi-fluid pulp, which approached very nearly the anterior surface, and was the cause of the spot seen there externally. A considerable thickness of firm white matter existed posteriorly between the surface of the cord and the red pulpy matter of the interior. A much thinner layer of white matter remained anteriorly. The interior of the cord was converted into red pulpy matter, for the extent of one inch and a quarter, the middle of this space being exactly opposite the root of the 5th cervical nerve, that nerve, namely, which passes out between the 4th and 5th vertebræ. When the cord was removed from the vertebral canal, the anterior surface of the latter presented a trifling projection, corresponding to the junction of the bodies of the 4th and 5th vertebræ. The arches of the vertebræ had not been displaced so as to encroach on the diameter of the canal.

Head not opened.

Lungs slightly congested posteriorly, but otherwise quite natural.

No morbid appearance in the abdominal viscera.

Kidneys of a purplish colour, otherwise quite natural.

Mucous membrane of the bladder pale and smooth,

excepting a small patch on the posterior surface, exhibiting vascularity.

The only points I wish to notice in this case at present, are, that the excited movements were much more feeble at first than a few days after the accident, and that the priapism was not removed by catheterism.

In two other cases of paraplegia, from injury to the spine, which were observed by Mr. Busk, involuntary movements could not be excited at all. In one of these there was only partial loss of voluntary power, occasioned by a blow on the loins and sacrum; in the other the shock and injury were very great, and the patient died 68 hours after the accident, so that it is probable the lower part of the cord had not recovered from the concussion received.

Mr. Grainger has also kindly sent me some interesting cases of paraplegia, attended with susceptibility to excited movements in the palsied limbs; but as they do not establish any facts other than those observed in the cases already related, I refrain from giving their details, being unwilling to occupy further the time of the Society.

The following is a summary of the leading facts observed in the preceding cases, and of the inferences that may be drawn from them.

1st. That the involuntary movements excited in the palsied limbs, were the same in kind as those observed in decapitated animals.

2nd. That these movements were quite independent of sensation, and that they varied in extent

and force, inversely with the degree of voluntary power possessed by the affected limbs; being the most forcible when the loss of voluntary power was complete, and diminishing gradually in extent and force as that power increased.

Here is the place to inquire whether this susceptibility to involuntary contractions in muscles that do not commonly exhibit it, was owing to increased activity in the motor function of the cord, excited by the irritation of the injury, or was merely the consequence of the withdrawal of volition. *A priori*, it would seem that the mere withdrawal of volition would be sufficient to create this susceptibility; that the motor power of the cord not being expended by volition, would accumulate so as to become excited to action, by impressions on incident nerves,—the normal mode of action in involuntary parts,—and that those muscles which generally act under the influence of volition, would thus be excited to involuntary contraction. But in hemiplegia from hemorrhage on the brain, it rarely happens that involuntary contractions can be excited in the palsied limbs, though the loss of voluntary power be as complete as in the cases I have described; this is not conclusive, however, against the hypothesis, because the analogy between the cases is not complete. I infer, therefore, that these involuntary contractions, when powerful and extensive, are evidence of increase of motor power in the cord, which the withdrawal of volition in some measure favours; but that in the cases I have related, it is probable from the nature

of the lesions, as also from the appearances observed in the fatal cases, that irritation of the cord was the main cause of increased activity of its motor function.

3rd. Irritating one leg generally caused movements in that leg only; in some cases it caused movements, but more feeble ones, in the other leg also, and in the arms when they too were paralysed: facts completely analogous to those observed in decapitated animals.

4th. Impressions on the soles were more efficient than any that were tried on other parts of the skin in exciting involuntary movements; and heat, although not producing sensation, was a powerful means of excitement.

5th. In one case, impressions on nerves arising above the seat of injury, excited convulsions in parts receiving their nerves from below; a fact which proves, that influences from impressions received on incident nerves, at any point, are diffused through the cord. This leads me to remark that convulsions are rarely, if ever, spontaneous, in the strict sense of that word, for the multitude of impressions constantly received on the surface, especially in the mucous membranes, are probably sufficient, when the motor function of the cord is much exalted, to excite all those convulsions usually called spontaneous.

6th. That the convulsions observed were not associated with a sense of fatigue, but that the power which caused them was subject to exhaustion,

and renewed by rest. In cases of injury to the spine, some time elapsed before the palsied parts exhibited involuntary movements; this was probably owing, in some measure, to concussion of the cord, for in decapitated animals these movements may be instantly excited.

7th. Strychnia given internally increased the susceptibility to involuntary movements, and caused spontaneous convulsions that were limited to the palsied parts.

Prussic acid, as well as tincture of digitalis had a decided effect, in one case, of suspending or quieting spontaneous convulsions.

8th. That the dependence of priapism on distension of the bladder, observed in one case, tends to show that external impressions may be reflected by the spinal cord, so as to excite organic processes,—such as, vascular turgescence,—in the same manner as to excite muscular contractions.

I shall now notice a circumstance in the pathology of tetanus, which gives that disease a link of connection with the preceding cases, and which has been overlooked by many physicians, and has received from none the attention it deserves: I allude to the fact that the convulsions of tetanus, when already present, are rendered much more powerful by impressions made on the skin or senses, and when absent, as in the intervals which usually occur, may invariably be excited by such impressions. The fact is stated by Dupuytren in his "*Leçons sur les plaies par les armes à feu*," in the following words:—

“ L'intelligence des malades reste ordinairement saine ; rarement il survient du délire. Cependant la sensibilité est très développée, et à mesure que la maladie marche, ou la voit s'accroître de plus en plus, et se monter à tel point que le moindre bruit, la moindre secousse, les plus faibles émotions suffisent pour la mettre en jeu et faire entrer le système nerveux, et le système musculaire qui est sous sa dépendance dans un état de convulsion.”

It is therefore of great importance in the treatment of this disease, to avoid multiplying impressions, especially those of a painful kind. In this point of view, the practice of applying leeches repeatedly, and in great number, is very objectionable, for it is not questionable that the evil here alluded to is not compensated by any ascertained advantage. Repeated cupping, blistering, and also repeated purging—means often employed—are open to the same objection. While on this topic I may be allowed, also, to question the propriety of giving opium in the treatment of tetanus. It has been ascertained that the effect of that drug is to excite, and not quiet, the motor function of the spinal cord ; indeed, it is well known that the motor acts of the cord may be rendered much more active and powerful by giving, before decapitation, opium to animals that are to be subjects of experiment. Believing that, after ample trial, experience has not established any advantage in the use of opium, I consider these objections, furnished by theory, to be motives sufficient for its future exclusion from the treatment

of tetanus. If in the choice of remedies we are to be guided at all by physiological considerations, it is much more rational to seek for remedies for tetanus in that class of substances known to exercise sedative influence on the motor function of the cord. I may mention hydrocyanic acid, conium, and digitalis, as deserving more ample trial than has yet been given them.

Hitherto, the treatment of tetanus has been conducted in violation of all known physiological principles: it is to be hoped that our improved knowledge of the functions of the spinal cord will at length lead us to discovery of more successful methods.