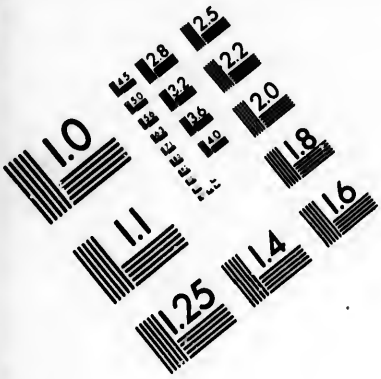


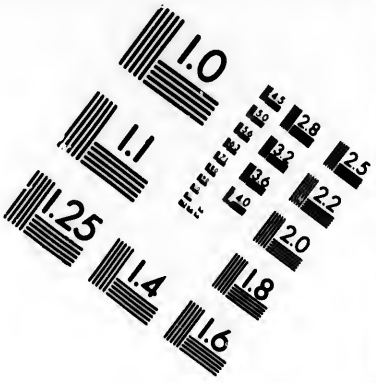
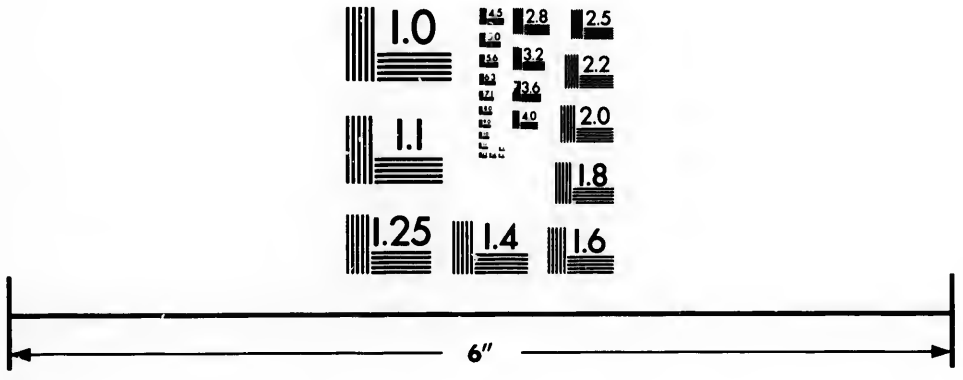


IMAGE EVALUATION TEST TARGET (MT-3)



Photographic Sciences Corporation

23 WEST MAIN STREET
WEBSTER, N.Y. 14580
(716) 872-4503

Technical and Bibliographic Notes/Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming, are checked below.

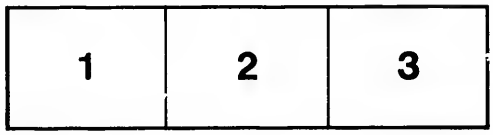
- ☐ Coloured covers/ Couverture de couleur
- ☐ Covers damaged/ Couverture endommagée
- ☐ Covers restored and/or laminated/ Couverture restaurée et/ou pelliculée
- ☐ Cover title missing/ Le titre de couverture manque
- ☐ Coloured maps/ Cartes géographiques en couleur
- ☐ Coloured ink (i.e. other than blue or black)/ Encre de couleur (i.e. autre que bleue ou noire)
- ☐ Coloured plates and/or illustrations/ Planches et/ou illustrations en couleur
- ☑ Bound with other material/ Relié avec d'autres documents
- ☐ Tight binding may cause shadows or distortion along interior margin/ La reliure serrée peut causer de l'ombre ou de la distortion le long de la marge intérieure
- ☐ Blank leaves added during restoration may appear within the text. Whenever possible, these have been omitted from filming/ Il se peut que certaines pages blanches ajoutées lors d'une restauration apparaissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.
- ☐ Additional comments:/ Commentaires supplémentaires:

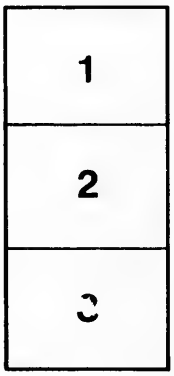
L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

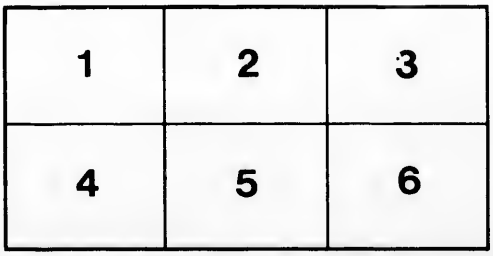
- ☐ Coloured pages/ Pages de couleur
- ☑ Pages damaged/ Pages endommagées
- ☐ Pages restored and/or laminated/ Pages restaurées et/ou pelliculées
- ☐ Pages discoloured, stained or foxed/ Pages décolorées, tachetées ou piquées
- ☐ Pages detached/ Pages détachées
- ☑ Showthrough/ Transparence
- ☐ Quality of print varies/ Qualité inégale de l'impression
- ☐ Includes supplementary material/ Comprend du matériel supplémentaire
- ☐ Only edition available/ Seule édition disponible
- ☐ Pages wholly or partially obscured by errata slips, tissues, etc., have been refilmed to ensure the best possible image/ Les pages totalement ou partiellement obscurcies par un feuillet d'errata, une pelure, etc., ont été filmées à nouveau de façon à obtenir la meilleure image possible.

This item is filmed at the reduction ratio checked below/
Ce document est filmé au taux de réduction indiqué ci-dessous.

10X	12X	14X	16X	18X	20X	22X	24X	26X	28X	30X	32X
						✓					







Bra

THER
to acc
based
fortify
or mer
and he
rate ou
but di
general
sufficie
the ba
Richet,
the Ce
face: "
treat h
trary, v
defects
real se
incite
conclus
ill-dem
and int
the adv
siasm."

This
tor sho
conclus
sufficie
adduce
can sta
its par
body.
structu
mental

Brain Lesions and Functional Results.

By DANIEL CLARK, M.D., Toronto.

[Read before the Canada Medical Association, at Ottawa, September 1st, 1880.]

There is great danger in medical research to accept as theories preconceived notions based on a few isolated cases, and then to fortify these dubious interpretations of physical or mental phenomena by dragging in, neck and heels, every iota which seems to corroborate our views. On the other hand, the ardent but discreet investigator will adopt no great general principles until he has at his command sufficient data upon which to base them, beyond the bare presumption of vague probabilities. Richet, in his "Histology and Physiology of the Cerebral Convolutions," says in the preface: "There is nothing more baneful than to treat hypotheses as certainties. On the contrary, when serious criticism has revealed the defects and feebleness of an experiment, a real service has been rendered, for it may incite to new experiments and unequivocal conclusions. Inductions from probabilities or ill-demonstrated experiments are unreliable, and intelligent scepticism is more valuable to the advance of science than unbridled enthusiasm."

This honest expression of such an investigator should lead us to pause before drawing conclusions and establishing theories with insufficient proofs. It will be seen in the cases adduced of lesion of the brain, that this organ can stand more rough treatment in many of its parts than almost any other organ of the body. In fact, such laceration of its delicate structures can take place without any serious mental or physical disturbance, that we almost unconsciously take for granted that many parts of it must be of secondary importance in the animal economy. It is true that a large majority of those injured in the brain are afterwards afflicted with such diseases as epilepsy, paralysis, head distress, loss of memory, and the like; yet it is remarkable how many examples of the most extensive lesions of the brain can be found with no such results. In a monograph published by me a short time ago, I endeavoured to show that localization of functional power resided only in the basal ganglia, and that the masses of cerebral substance above them were only depositories of nervous energy. If this opinion be based on a physiological fact, it would help to solve this enigma.

It is well known by all medical readers that a sharp controversy has been carried on, and antagonistic opinions have been uttered by the leaders of thought in our profession, on the functions of the convolutions of the brain. They have been mapped out with the accuracy of the streets of a city, and each district has been allotted its own work to do. Although no dividing line exists in the substance of the brain, yet the comparatively slender divisions of many of the sulci are made to be boundaries of functional energy, in which great differences of operation exist. It is not the province of this paper to take up this subject in detail, but rather to show by the record of cases how foreign bodies and diseases can virtually destroy many of these so-called

centres without any commensurate functional disturbance such as might be expected if these parts were distinct organs; also to show that mentality is not interfered with in these cases to the extent which at one time we were led to believe. The psychical results would be a good nut for the bumpologist to crack in these days of infidelity in the doctrines of Gall and Spurzheim.

All anatomists know that although the fissures of the brain in man maintain a certain degree of uniformity in direction and outline, yet the differences in detail are considerable. It will also be observed that these fissures do not make distinct divisions of the surface. The even continuity of the surface of every convolution, by means of an isthmus (so to speak) at the extremities and sides of each, indicates no striking dividing line between each of them. The dips in the grey matter, lying underneath these fissures and in proximity to the white substance, show that a certain degree of uniformity in quantity of grey matter is present throughout the periphery of the brain. It is true that differences in cell formation are seen in the various layers of the cortical substance, but these cellular distinctions are found only in each layer. There is no physiological distinction found in the various convolutions distinct from one another, to account for the varied functions in these so-called motor centres, as claimed by the Ferrier school. The uniformity of cell structure in the separate layers of the cortical substance is continuous, and nowhere bounded by the surface fissures and convolutions. In other words, all the convolutions are similar in structure, and were sections of each cut out from without inwards, and submitted to the closest analysis, no microscopist could tell where to locate each part. All are as uniform as would be sections of the cortical substance of the liver or kidney. If we compare the convolutional structures of the cerebrum with that of the cerebellum, it will be seen that they are constructed on the same plan (Richet). In the region where the distinctive giant cells exist (*i.e.*, in the fine layer type of the ascending frontal and parietal convolutions), all the cortical regions of grey matter have no distinctive anatomical characteristics except the presence of giant cells. Charcot suggests that all the different sized cells may be of the same kind in different degrees of development. In this way he thinks it possible that even motor centres may change their centres. This is a convenient theory to account for the fact that such an attack as aphasia often passes away, although its so-called motor centre remains impaired.

This want of dividing lines on the external surface of the brain is, on physiological grounds, a momentous objection to distinct centres in the cortical substance. Let us now consider this subject from another point of view. Fritsch, Hitzig, and other experimenters, agree that in no appreciable degree do mechanical or chemical agents excite motion in the cerebral substance. Excitation by galvanism is said to be very feeble and very limited in either the cerebrum or cerebellum, and this want of response is seen throughout. It is evident that in this way—powerful as the agent is—no functional centre could be found on the surface. Herrman shows that even after the grey matter is destroyed by chemical cauteries, a very feeble current of galvanism applied to this surface produced a slight movement, and significantly adds that in cutting away slices from the brain, the effect was more decided in proportion as the *central regions were approached* (Richet). In other words, the focus of nerve energy seemed to be in the ganglia at the base of the brain, and that the destruction of the cerebral substance did not produce that disturbance of the system commensurate with the loss of substance once supposed to be so necessary to the continuance of physical life and mental action.

Richet says, in speaking of the localization theory as propounded by Ferrier and his ardent followers, that "Absolute inflexible localization of the motor zones is impossible. There are zones which encroach upon each other, but none of these zones have limits of determined, vigorous constancy. The best proof of this is the difference existing among authors." If this mean anything, it is that although paralysis and abnormal functions of the brain in many instances follow the destruction of certain cortical parts, or are the results

of disease, and although a certain degree of uniformity in physical results follows, yet it is equally true that these same areas may be destroyed without any such manifestations following Their own experiments are taken as proofs of this fact. These circumscribed areas cannot, therefore, by any show of reasoning, be *the* organs which are the centres of distinct functional activity. These local changes may affect the co-ordinating and mental powers, but the centres of these activities must be sought for elsewhere.

To reconcile these undoubted variations in results, and possibly arrive at the truth, let it be assumed that the basal ganglia are the centres of these functions. Let it also be assumed that the cerebrum and cerebellum are not directors of motion, but only *conservators* of nerve energy, both receptive and functional. Let us say that these ganglia are focal centres to all the nerve tracts of the system. Whatever nerve injury may do in other parts of the nerve mass within the skull without dangerous results, it is evident by experiments and the havoc of disease, that no serious impairment can take place in all or any part of these ganglia without disaster; hence their supreme importance: in fact, this focus of influence might be called the metropolis of life. Maudsley, in "The Pathology of Insanity," says: "The disturbance of the cortical cells is in reality secondary; it is a reflex functional result of the primary morbid action that is going on in the neighbourhood." And again: "Portions of the hemispheres may be cut away without the patient feeling it, though he is fully conscious." Ferrier locates the motor centre of the opposite upper limbs in the upper part of the *ascending frontal convolution:* in the *first frontal convolution*, the movements of the head; in the *second or centre convolution*, the motive power of the facial movements; and in the *third convolution*, the centre of the movements of the tongue and lips in monkeys, and the centre of the faculty of articulate speech in man. This is often called Broca's convolution In the *superior parietal* lobe is located the centre for the movements of the lower limbs.

The *gyrus angularis* is said to possess some influence over sight. Dr. Laffont, in a paper read before the Paris Anatomical Society of last year, states that "the centre which controls the circulation of the abdominal viscera is in the floor of the fourth ventricle, because local irritation of this part produces unusual activity in the blood movement of the liver and intra abdominal organs." Other investigators equally credible say that the grey substance of the fourth ventricle is the motor centre of respiration; the occipital lobes, the centres of vision.

Aphasia, or the loss of ideo-motor coördination, is circumscribed by some to disease or injury of the posterior part of the third left frontal convolution. In passing, it may be said that Ferrier still farther divides his functional foci, and puts "subjective auditive sensation" in the first temporal convolution, and "subjective olfactory sensation" in the cornua ammonis. In short, it may be said that, in cerebral localization, the encephalon does not represent a homogeneous organ, an unit, but rather an association or a confederation composed of a certain number of diverse organs. To each of these organs belong distinct physical properties, functions, and faculties (Charcot). It is well to keep these views in mind and see if they are corroborated by facts.

It is to be remembered that there is no direct nervous communication with the body from the cerebrum and cerebellum except through the basal ganglia, notwithstanding statements to the contrary. Whatever injury disease or traumatic lesion may inflict on these upper nerve masses with comparative impunity, analogous injury from the same causes cannot be inflicted on the central or base organs without dangerous results. In other words, these are, in my opinion, the true motor and sensory centres of the system, and there is no necessity of going beyond them to prove a localization theory. The distinction between these by well-defined boundaries and the want of uniformity in structure point strongly to distinct functions. The outshoot of the spinal cord, and the numerous nerve ramifications, t only to the organs of special sense, but also to the locomotive and organic systems,

point out these districts as being the peculiar focal centres of functional and psychical life. If this theory be correct, it can explain all the phenomena manifested by experiments made, and pathological conditions found, on the cortical substance, without resorting to the chart made out by such shifting, incomplete, and changeable boundaries as the sulci of the convolutions afford. The "bumpologist" conveniently locates all mental centres in the cortical substance nearest to his manipulations, and ignores all the similar surfaces at the base and between the hemispheres, because this *terra incognita* is not convenient to map out. He cannot reach these parts; therefore they must be useless appendages. He forgets nature has no lumber room. In somewhat the same way the Ferrier school of investigators find certain functional disturbances following the abrasion, excision, or galvanism of definite cortical parts, with a considerable degree of uniformity. Based on these manifestations, already, with considerable confidence, it is said nearly all the functions of the body are located on the exterior part of the nerve mass, which is within reach of experiment, and somewhat hasty conclusions are drawn from the results. All the rest of the brain mass, which has a substance exactly similar in structure to the external grey matter, is practically ignored, in spite of its paramount importance, which is evident from the complexity of the structure, and from the fatal results which flow from injury to these central parts. It seems to be overlooked that any injury to the cortical substance must necessarily affect the lower ganglia, to which it lies in juxtaposition, and to which it stands so nearly related. The periphery of the brain doubtless has much to do in stimulating to action these centres. In the latter are found the distinctive seats of functional activity, and in the superimposed mass the residuary power to impel, but not to direct—to give additional vitality, but not to indicate the mode and direction this force is to take. This discriminative power is left to be performed by these central glands, which are safely situated in the centre of these sympathetic and active auxiliaries. Not only is this true in respect to function, but it is equally true as respects sensation. Sensation and function have a community of interests, and are *focalized* together. Dr. Symonds, in the Gulstonian lectures, says: "Pain does not seem to be in the nervous matter, whether vesicular or tubular, of the cerebral hemispheres, or of the cerebellum. No evidence of feeling has been obtained by vivisectors till they approached the sensory ganglia—the *thalami optici* and *corpora quadrigemina*. But these are the centres of sensation to all parts of the body as well as to the head."

It is satisfactory to see that recent investigators are paying more attention to the central organs. Their researches go to show that very important functions are likely to be found having their excito-motor centres in the internal parts of the brain. These experiments, as far as they go, point to the probabilities of my theory of localization. Richet, in speaking of cerebral excitation by means of electricity, is forced to say in explanation of certain phenomena, "Known facts demonstrate that excitation of the convolutions which surround the sigmoid gyrus act with extreme energy upon the ganglionic centres of the brain (opto-striated bodies). It is possible that such excitation culminated in the cerebral centres, and that these centres thus surcharged discharge to the muscles." Charcot says, in speaking of the lenticular nucleus of the *corpus striatum*: "These grey nuclei are possibly so many centres endowed with distinct properties and functions." This is a germ idea of the theory which I propounded several years ago in the following words: "Large portions of the cerebrum and cerebellum may be taken away from the living body without immediate danger of death; but the organs in the base of the brain, from which spring the numerous nerves so essential to life, cannot be touched in vivisection or by disease with impunity. From this central region nerve influence radiates to every part of the body, making its connections with the depositories of nerve power in the spinal cord and with the ganglia of the sympathetic system."—(*Vide* "An Animated Molecule," p. 38.) If Charcot had added to his hypothesis the probability that the base and central ganglia were the true and

only motor centres, a solution of the difficulties which surround the Ferrier system could be arrived at without ignoring the doctrines of localization. Let the area be circumscribed to really the most vital parts of the brain, then, could all phenomena be explained. It would then become more evident why traumatic injury and destruction from pathological processes are not always followed by functional and mental unsoundness. If this explanation be accepted, it will be seen that the surfaces and upper portions of these nervous masses thus become adjuncts to vital organs in the centre and base of the brain. The former, in their analogy of structures and juxtaposition, give power but do not impart function; they are auxiliaries, but not necessities, to the ganglionic centres; they intensify energy, but do not direct; they are, as it were, additional cells to the battery, but are not its controlling agency. I repeat this view in another form to avoid ambiguity and misconception.

It is worthy of remark in this connection, as it is a matter of experiment, that such a large area as the Rolandic zone can be destroyed, and yet leave the intelligence unimpaired. A considerable portion of the frontal or even of the occipital lobes can be removed without any apparent alteration of the intellectual powers. The corresponding lobes of either the frontal, occipital or parietal regions have been destroyed without affecting the conscious being, or those functions said to have their seat of power in these parts. It is evident then that these are not the *sole* habitations of mind or certain physical operations. The reciprocity between mind and body is strikingly seen in aphasia. There can be no aphasia without more or less impairment of the memory, judgment and imagination. Yet this functional and mental disorder can exist either with or without injury to the third frontal convolution. What basis then is there to suppose it so necessary to certain physical operations?

If it could be shown that sight, hearing, tasting, often were accomplished when the optic, auditory, and gustatory nerves and the region of their insertion, were destroyed, then would it be plain that these were not the only tracts of nerve influence for these centres of special sense to reside in, nor the avenues of each peculiar manifestation of sensation. In the same way, if we can have aphasia, paralysis of the legs, arms and face, with these so-called centres of nerve force unimpaired, or if impaired without these results, then is it beyond controversy that this doctrine of the cortical localization of specific functional energy is not proven. What may be in store in the future for these earnest and honest workers is only a matter of conjecture. As Richet pertinently says (page 115), "If the convolution which surrounds the crucial furrow is really the motor centre of the legs, then by removing both right and left convolutions the legs should become paralyzed; if not, then is it not a true motor centre. It would then be necessary to admit that there are several organs for one function, several motor centres for one limb, which is contrary to probability and to fact." He suggests as a way out of the difficulty that as the spinal cord conduction (according to Vulpian) is carried on equally by all parts of the grey matter, it is possible that the same indifference holds for the brain, though less in degree. In other words, *there are habitual roads, but no compulsory ones.* This view would be, if true, a death blow to the organic local theory as applied to the cortex. This theory would not meet Ferrier's definition of localization, which is said by him to be "a complex arrangement of individually differentiated centres, which in associated action regulate the various muscular adjustments necessary to maintain equilibrium of the body."

It will be seen that so far the greatest interest centres round the third left frontal convolution, on account of the stress laid on the fact that aphasia is so often found as a result of its injured or diseased condition. If it can be proved that this imperfection of speech is always conjoined with an impaired condition of this locality, and *never otherwise*, then is the battle won for localization of functional power in the cortical substance, for it would be fair to infer that other centres for other functions would be found in similar parts of the same field of investigation. Unfortunately for this doctrine, the exceptions to these

results are too many to be ignored, and these show that this spot is not the centre of speech, nor its injury the sole cause of aphasia. It has been found in numbers of examples that aphasia is found with this convolution intact. Not only this, but it is known that speech, in its different forms of language, such as writing, reading, singing, drawing, and imitation—in fact, aphasia in all its forms—follows lesion in the Island of Reil. (*London Lancet*, Amer. Ed., July 1880, p. 34.)

Aphasia is known to exist as the result of disease in the right hemisphere, and that not in the corresponding third frontal of that hemisphere. It cannot be supposed this reputed motive brain tissue which excites the functions of speech may be destroyed, and yet the peculiar energy which animates it can remain unabated after its obliteration has taken place, unless it is claimed that the corresponding convolution on the right, in a vicarious way, does the work of its fellow. If such were the case, then the third left frontal convolution could claim no pre-eminence as the sole seat of the faculty of articulate language. To get over this difficulty, this school of thinkers introduces what is called *the theory of supplementation.* They say some other part of the cortical substance comes to the rescue when any centre of function is destroyed. This neighbourly assumption of peculiar and distinct labour is not found in any other part of the system, however willing the organs may be to give a helping hand to one another. We are told it may be the corresponding part of some other cortical area. This is virtually a giving up of the doctrine of these so-called "true motor centres."

Here let me say, in passing, that a fallacy in vivisection often arises in forgetting that experiments on the brains of inferior beings by the destruction of parts do not always produce analogous effects on man when corresponding parts are injured. We may remove the whole of a cerebral hemisphere of a pigeon or rabbit with the only functional result of a slight impairment in flying or jumping. No hemiplegia will follow, such as is the case with like injury to the dog or monkey. Man is much more sensitive to such lesions, only in certain parts. In fact, the whole brain may be removed in many creatures without affecting their locomotion. We know that in man disease, such as sclerosis, and softening, may cut off the spinal cord from cerebral influence, yet functional activity goes on with unabated vigour. In the same way, we find that if the base and central organs remain unimpaired, no marked symptoms arise, except by sympathetic connections with adjacent parts. This shows the fallacy of reasoning by analogy between man and animals based on experiments. There are common results and also great differences.

It is now important to say a few words about the circulation of the blood in the brain, to show how much more plentifully the centre and base are supplied with blood than are the superior parts of the cerebrum and cerebellum. *It is not to be forgotten that where the largest supply of blood is needed, there is found the greatest functional activity.* We are all well acquainted with the wonderful distribution and anastomoses of the blood in the base of the brain, both in the circle of Willis and in the cerebral arteries springing from this polygon of vessels. We are also aware of the fact that two sets of branches shoot from these main trunks in almost parallel lines. The one class goes into the medullary and cortical substance in an outward direction from those central reservoirs, but does not reach the surface. Another class runs to the periphery and forms the *pia mater*, from which branch inwards numerous arterioles to supply the cortical and medullary parts not reached by the vessels springing from the centre. These two sources of supply are not only distinct as between each of their own vessels, but also unconnected to a great extent with one another. The anastomoses between these two sets of vessels is very slight indeed. The streamlet in each can be dried up or seriously interrupted in many ways without disturbing the neighbouring vessels to any appreciable degree. This accounts for so many circumscribed lesions in these parts, and for the little effect they produce on the adjacent tissues and circulation. I am inclined to think, that on account of this localization of circulation, and consequently a tendency to restricted

areas of disease, a good many fallacies of reasoning have obtained currency in respect to centres of function. Heubner cites pathological cases which indicate that obliteration of one of the large vessels of the cortical system, or any of its branches, has during life given no pronounced symptom. (Charcot.)

Let us now turn to the arterial circulation in the *grey central ganglia*. This section includes the *thalami optici*, the *corpora striata* and their appendages. It needs only a moment's reflection of our anatomy to realize that the central ganglia are largely supplied from the Sylvian artery, as well as from the nutrient vessels, which spring in large numbers from all the cerebral arteries and from the basilar at its bifurcation. The sum total of all these shows a much greater capacity for blood supply per square inch than in any other part of the brain. Such being the case, we know this augmented normal supply means proportionally increased activity. Hence it follows as a matter of fact that any abnormal increase or decrease of blood means a greater or less physical or mental perturbation. Congestion, as well as anæmia, is followed by the same results—that is, more or less suspended sensibility and retarded voluntary action. Where the blood supply is found to be naturally the most copious, there is greater susceptibility of this kind, and as a corollary it may be added, there is functional activity in proportion to the normal blood supply. The difference in this respect between the cortical substance and the central parts is most marked. This points to the former as being only subsidiary to the latter, taking the circulation as a physiological basis to judge from in this respect. Although the central and base ganglia are much less in bulk than is the cortical substance, yet, about one-half of the blood which enters the encephalon is distributed to the former. It would be interesting to know if this unequal supply has anything to do with the pathological fact that in hemiplegia from cortical disease we find it "limited, transient, and variable" (Charcot), but in paralysis of the body from central disease it is permanent, general and uniform. It is a pathological fact that paralysis, general or partial, can be produced by *any part* of the brain being affected with inflammation, embolus, or tumour; showing that loss of function is not consequent on degeneration or destruction of some localized spot. That part of the brain which demands the greatest amount of blood in the performance of its work must necessarily have the greatest activity.

Let me then repeat in another form that a very superficial knowledge of the brain circulation indicates how direct and ample is the blood supply to the base and central ganglia in comparison with the cortical supply. This is especially true of the arteries which run to the *corpus striatum* and *thalamus opticus*. The cortical substance is nourished in a roundabout way through the *pia mater*, but the central system is reached directly through the large central vessels springing from the circle of Willis, which furnish a perfect fountain of blood supply near at hand. So distinct and important is the circulation in this grand centre, that when obliteration of the Sylvian artery takes place, all the ganglionic centres are affected, and cerebral hemiplegia accompanied by hemianæsthesia is the result. This physiological fact alone shows the greater importance these ganglia hold—it seems to me—as functional centres in comparison to the cortex or even the entire hemispheres. Since writing the above, I find that Prof. M. Schiff, of Florence, has caught the same idea, when he says, in his monograph on "motor centres," that "human and comparative pathology have stated with certainty that the motor centres do not extend above the base of the brain." Unless my attempt to be brief has led to ambiguity, it will be seen that among the probabilties of this obscure subject, the explanations I have given in defence of the theory enunciated are based on—

I. The radical difference found in the circulation of the blood, both as to mode of distribution and quantity, leading to the reasonable inference of greater functional activity existing in the centre than in the circumference of the brain. The more life-action in any part, the more is blood supply needed.

II. The want of uniformity in functional results, when definite and alike portions of the

cortical substance are stimulated, impaired or destroyed; hence, this cannot be the seat of so-called true motor centres.

III. It would be consonant with pathological and experimental facts to locate these motor and physical centres in the base and centre ganglia; yet in sympathetic relations, being influenced, but not absolutely controlled, by the cortical substance.

IV. The want of distinctive physiological features in the different convolutions.

I will now give a few examples of brain injury, illustrative of these views. The first are culled from the surgical records of the war of the late American rebellion:

Private Hughes was wounded at the battle of Antietam. The hospital reports say that the injury was a perforation of the skull by a single conoidal musket ball entering near the inner posterior angle of the right parietal, and emerging at a higher point of the left parietal, making, after traversing a portion of the brain, a large exit wound. At the time of this extensive injury he dragged himself from the field, but *he did not lose his consciousness.* Eight days after the injury, it is reported the general condition of the patient was good; suppuration had commenced, no febrile action existed, the pulse was regular; sleep not materially disturbed, *mind clear*, and manifested no signs of compression of the brain, or inflammation of its membranes. When the swelling of the scalp subsided, a prominence of brain substance was found—one inch in height, and three inches in length—in which the pulsation of the arteries could be distinctly observed. Spiculæ of bone came away from time to time, and the tumour subsided within the cranium. On December 20th, 1870, or over eight years after the injury, he was examined by two medical men. Previous to this time he had worked in an iron foundry. His memory remained quite good. He had no paralysis, and it is reported by Drs. Keen and Thomson that it is remarkable to observe the almost entire restoration of his mental faculties, especially in view of the probable deep lesion of the brain, both by the primary injury and the subsequent fungus cerebri.

It will be seen that in this case there was no functional disorder, except that, for a short time at first, "the brain functions seemed clouded." This might be expected for a time.

Private Sheridan was shot through the left temporal region. The missile lodged in the brain and was never extracted. At the close of the war he was discharged—recovered, and received no pension. No functional disturbance.

Corporal Farnum, wounded by a round ball entering the cranium and brain matter. He recovered, and was put on the Veteran Reserve Corps. He was not pensioned. He was none the worse for the wound.

Private Dillon was wounded by a bullet which entered the cranium very near the superior angle of the occipital bone, and had passed anteriorly into the substance of the brain. He lay on the field of battle two days without any attention. After being a year invalided he returned to active service, perfectly well physically, but with the intellect slightly impaired. Afterwards he was mustered out of the service perfectly well, and was not pensioned. The ball was not extracted. After the first shock there was no functional disturbance.

Private Bemis, wounded by a ball entering a little outside the left frontal protuberance, and passing backwards and outwards. It removed a piece of the squamous portion of the temporal bone, with brain substance and membranes. When the patient entered the hospital, brain matter was oozing from the wound. At first, respiration was slow; pulse 40; the right side was paralyzed, and there was total insensibility. Three days after the injury the bullet was extracted from the substance of the left hemisphere. It was a conoidal ball and badly shattered. He then rapidly recovered, and the report says that in four months and a half afterwards "the mental and the sensory faculties were unimpaired." On October 30th, 1870, he wrote: "I am still in the land of the living. My health is good, considering what I passed through. My head aches some of the time. I am married and have one child. My memory is affected, and I cannot hear as well as I could before I was wounded." These were the only results of this

extensive laceration of brain matter. The slight functional disturbance did not correspond with the doctrine of cortical functional centres.

Sergeant Rotherham, wounded at Gettysburg by a musket ball, which penetrated the skull near the right frontal eminence, passed directly inwards and lodged somewhere on the membranes or in the brain substance. The opening through the bone was similar to that made by a trephine, and the track of the ball could be followed on the *dura mater* with a probe for a considerable distance, as that membrane was detached from its natural connection with the skull. The ball was not extracted. There was no perceptible loss of power, motion, or sensation on either side of the body. There was no arterial excitement His recovery was rapid, and five weeks after the injury he was furloughed for fifteen days, at the expiration of which time he returned to duty, having suffered no inconvenience from the injury. After this several bones exfoliated, but his mind was not impaired to any perceptible degree. For some time after the wound was received, he was assigned light duty in the Veteran Reserve Corps Hospital.

Lieut. Brown, at the battle of Wilson Creek, received a penetrating gunshot wound of the cranium and brain. The ball was not removed for seven years after the injury, but in a few days after being wounded he was fit for duty. In January, 1871, this officer was on duty as captain in the 13th Infantry.

Private Stallman, wounded at Winchester by a musket ball, which entered at the right temple and emerged at the opposite side of the head. In spite of this serious lesion of brain, in a few months he was put on light duty. He had no strabismus, and we are told that, although his mental faculties were slow and uncertain and his memory impaired, he had no hallucinations nor mental aberrations. The year following the injury he was pensioned. No functional impairment except the above mentioned.

Private Haggart was wounded by a conoidal musket ball, which struck the left side of the head, and passing through carried away a large part of the left half of the occipital bone. At first he became insensible and lost more than an ounce of cerebrum, leaving bare the meningeal artery. Seven months afterwards he was discharged from the hospital. At that time both eyes were dilated, causing dimness of vision, but his intellect was good, and he could read very coarse print. He died four years afterwards, but it is not recorded what was the cause of death. This extensive lesion only produced these slight results.

Sergeant Woodman was wounded by a gunshot missile, which entered above the left frontal eminence and emerged at a point one inch behind the upper margin of the right ear. He was unconscious for several hours. At the wound of exit eight small bones afterwards discharged. He was alive three years afterwards, and it was reported that the organs of special sense and the intellect were unimpaired.

Private Plumly was wounded by a conoidal musket ball, which entered at the inner angle of the left eye, and after passing through the brain substance it emerged behind the left ear. On March 7th, 1867, nearly three years after the wound was inflicted, he was in good health, and a pensioner. The only physical results were obscuration of the vision of the left eye for a short time, the discharge of pus from the orifice of entrance of the ball and through the right nostril and upper part of the posterior nasal cavity into the mouth.

Private Sechler was wounded by a conoidal ball, which struck the *os frontis* over the right eye and passed into the brain. He not only lived, but returned to duty six months afterwards, and was at the close of the war mustered out so well that he did not even receive a pension. The ball was not extracted. No functional results.

Private Samuel D. Solomon was wounded at Bull Run, Aug. 27th, 1862, by a carbine ball, which struck at a point two inches behind the tip of the left ear. The missile entered the brain to the extent of two inches and was not extracted. When struck he fell to the ground, but retained his consciousness. Healthy suppuration followed, and a fragment of bone was discharged from the wound. He suffered from headache, and also from acute darting pains across the base of the brain, from the right temple to the scar of the wound. No paralysis

existed, and the functions of the body were generally well performed. He afterwards served in a Washington Hospital in the capacity of nurse, and was discharged the service in the subsequent year, with no record of mental unsoundness or functional disability.

Corporal Wood, wounded at the battle of Winchester by a conoidal ball, which fractured the occipital bone and entered the brain. This was Sept. 19th, 1864. He was examined by a Confederate Board, on March 24th, 1865, whose members recommended that he might be employed at some post where the duties were not laborious, showing his mental faculties could not have been impaired to an appreciable degree. No functional results were seen.

Private Sheridan was wounded at the siege of Vicksburg by a canister shot. The missile entered the left parietal bone, immediately posterior to the coronal and three inches from the sagittal suture, passed horizontally inward, a distance of two and a-half inches and lodged. The ball could not be extracted. He suffered but little inconvenience. The wound suppurated freely, sometimes bled, and small fragments of bone escaped. Six months after, he was placed to work on the levee, and experienced no trouble, except on approach of a storm, when he had a dull pain and sensation of weight. In eight months after the wound was received he returned to duty.

Lieut. Lilycrantz, wounded at Fort Pulaski. The ball perforated the os frontis, over the right supereiliary ridge. When first seen after the injury he was vomiting freely, and about a fluid ounce of brain matter had exuded from the wound. A probe, five inches long, glided easily, by its own weight, its full length directly backwards through the wound without coming in contact with the ball. For ten days the patient showed a tendency to sleep, but was easily aroused and would converse freely, constantly wandering, however, from the topic of conversation. He could, at this time, neither taste nor smell, and his hearing and sight were much impaired. He recovered his mental faculties to such an extent as to be employed in Government service at Washington, and died five years afterwards. During this time he articulated distinctly; had no paralysis, but had occasionally slight attacks of epilepsy, but they were becoming slighter as time wore on.

I have culled these cases out of 559 persons who received penetrating or perforating fractures of the skull. These 559 were selected out of 4,350 cases of gunshot wounds of the cranium and its contents. Of that large number many were afflicted with functional and mental disturbance, but in no two cases of similarly injured were there like results.

Dr. Van Peyma gives a record of a singular case in the Buffalo *Medical and Surgical Journal*, December, 1873:—

A man, aged 50, was found comatose and brought to the Buffalo General Hospital. He subsequently was sufficiently roused to give his name and age. He died six days after admission. On *post mortem* examination, the meninges on the right side were found considerably congested. On removing the brain a collection of pus was found at its base, extending from the medulla oblongata forwards. The lateral ventricles were also found filled with a purulent collection. At this moment, as the incisions were being extended, something was heard to fall on the tray on which the brain was lying. To our utter amazement this was found to be a bullet. The ball, which was of small size and considerably flattened, had been liberated by the knife. The conviction was forced upon us (says the surgeon) that the external opening, through which the ball had passed, had been overlooked during the life of the patient, and that this was the real cause of death; but our astonishment was increased when, after a careful examination of the surface, no opening could be found. As a last resort, the cranium was examined from the interior; and on the anterior surface, above and a little to the right of the left orbit, was found a fracture of the frontal bone, the internal table of which was extensively fissured. With this as a guide, we again made search for the external aperture, and again failed in finding an opening, but finding a discolouration of the skin over the seat of the fracture, of a lead colour, circular in shape, and the size of a ball. There was not the least sign of a wound or the slightest scar. The

wound, which must have existed, had healed perfectly, and left nothing but this leaden discolouration to show its former presence. The course of the ball through the brain could still be traced by a probe to the place where it had lodged, near the anterior surface of the medulla. The opening in the bone was filled in with a gelatinous material through which tenaculum passed readily. There was no previous history of the case, but it was evident that the wound had been inflicted a considerable time before death; and seeing the patient had not found refuge in a poor-house, hospital, or asylum, the inference is fair that the intellect had not been much impaired, if any, up to the fatal attack. I am the more ready to think so, from the immunity enjoyed by patients similarly afflicted. There could not have been serious functional results as he had been able to look after himself.

A somewhat analagous case is recorded by Dr. Prewitt, of the City Hospital, St. Louis (St. Louis *Medical and Surgical Journal*):—A man, aged 32, shot himself with a pistol. The ball entered the forehead about an inch and a half above the supra-orbital ridge. He recovered in a little over a month, and *without marked impairment of intellect.* He died eleven months afterwards from erysipelas. No functional impairment is mentioned.

Asst.-Surgeon P. F. Harvey, U.S.A., reports the following case (*vide American Journal of the Medical Sciences*, July, 1879): It is that of an Indian Agency physician who received a Winchester rifle-ball three inches and a quarter above and one inch behind the right external auditory meatus. The missile took a transverse direction across both hemispheres toward the left supra-orbital convolution. A grooved director was easily passed in this track, a distance of five inches, without, however, reaching the ball. The patient did not lose consciousness on being wounded, and complained only of "seeing stars" and of some confusion of ideas. He recovered so rapidly that, after five days of convalescence, he took a journey of 90 miles, in December, in an open buggy, alighting several times to make his way on foot through deep snow-drifts. At the end of this exertion, however, two convulsions occurred, and the wound in the head re-opened. In a short time complete convalescence ensued. Six months after the wounding the patient travelled across the plains to his home in Indianapolis, and on his arrival reported himself in excellent condition.

Dr. Hopwood, of Ashton-under-Lyne District Infirmary, England, gives, in the London *Lancet*, an account of a case under his care last summer. A male patient, aged 28, was engaged in removing the centre support of the arch of a brick-kiln, and before he could get out of the way the arch fell, burying him and several others in the ruins. All the bones of the face were crushed in; and among other injuries the coronoid process of the lower jaw was broken off, and there was a depressed fracture of the temporal bone just above the zygoma, from which the brain protruded to about the size of a strawberry. The coronoid process of the lower jaw and the zygoma were removed, the protruding brain matter was shaved off and the temporal bone elevated. Temperature at this time was 99° Fah., pulse 62. The patient was perfectly sensible when brought to the Infirmary, and thought he was only slightly hurt. There was no shock, nor had there been any. The pupils were perfectly regular, and there was no paralysis. There was no mental disturbance at any time, and ten days after the injury he said "he felt as well as ever he did in his life." The injury was inflicted on 30th July, 1879, and on Oct. 14th following, he was quite well and working regularly.

John MacEvoy, of Paterson, N.Y., a lad of 15 years of age, was gathering sawdust in a sawmill last December. He had crawled under a circular saw going at a speed of 2,500 revolutions a minute. The saw was twelve inches in diameter, and nine inches of this was under the table. Becoming startled by a noise, the boy suddenly raised his head, bringing it in contact with the saw. The saw had made a clean sweep from the upper part of the frontal bone to the right side of the nose. The right upper eyelid was completely severed, but the eyeball was untouched. The cut was three-sixteenths of an inch wide, and the edges of the wound were smooth. The boy was able

afterwards to walk, and told how the accident had happened. He appealed to the physician to save his life, saying that he did not want to die. During the dressing of the wound the boy straightened up several times, and the physicians were obliged to tell him repeatedly to lie still. He obeyed as readily as a well person would and understood what was required of him. He took in his hand a glass of whiskey which was given him, which he drank without assistance. The accident happened on Monday; and during the week his intellect remained unimpaired until Saturday, when convulsions set in and he died. No *post mortem* was allowed by the parents, so the exact extent of the injury could not be ascertained. Taking the extent of the surface wound as a basis of conjecture, or, speaking mathematically, as the segment of a circle, the deepest serrated rim of the saw must have entered at least two inches into the skull and brain together. The cut was as clean as if done with a sabre, and was no doubt done almost as rapidly. Towards the end, paralysis set in; but, strange to say, the medical men differed as to which side or limbs were paralyzed. No functional impairment was seen until the boy was dying.

Dr. Quin, the Chief Surgeon of the hospital where the boy lay, gives another case which came under his notice years before. There was a boy named Murphy who fell out of a window of considerable height upon the curbstone in the street. He struck it with his forehead. When he was picked up, more than a teaspoonful of brain matter oozed out of his head. He got well, physically and mentally, and lived to be 22 years old, although he was only 5 years old at the time of the accident.

Of another case the doctor says: "There is Joe Murphy. You may see him almost any day walking round the streets here. He is lame and drags one foot a little. One day, in 1864, I was going along the street, when some people came running after me. I went into a basement and found Joe Murphy had been shot in the right eye two minutes before with a bullet 38·900 calibre. I probed the wound and found the bullet flattened against the back of his skull. It is there yet; but Joe got well, *and his mental faculties are unimpaired.* I've been intending to make a *post mortem* examination of his head, but I begin to think the old man will outlive me."

In the *Canada Lancet* of April, 1872, Dr. T. R. Dupuis, of Kingston, Ont., states the case of a boy who had been injured by a fall from a horse while going at a rapid rate. The lesion was a compound fracture at the middle of the superior portion of the left parietal bone, with considerable laceration of the brain. The broken piece of bone was nearly an inch and three-quarters long, three-quarters of an inch broad at one end, and three-eighths of an inch at the other. One edge of this piece was driven down into the brain in such a manner that its surfaces occupied a position perpendicular to their original situation, while the other edge remained *in situ*, being still attached to the solid bone by the *dura mater*, which formed a sort of hinge upon which the fragment turned. The history of the case states that the injury had been inflicted by the sharp edge of a stone. After exploring the wound with the points of the fingers—which passed in readily to the depth of half an inch or more—the fragments were extracted by means of forceps. Nearly a tablespoonful of brain substance was lost. At first, the patient was comatose. This state continued for two days. At the end of the second day he had lucid intervals. On the third day consciousness began to return, and with it voluntary motion. At this time the wound was discharging disintegrated brain matter, mixed with grumous blood and pus. Thirteen days after the accident the delirium was gone, but the mind was fickle and temper irritable and capricious. Without entering into the whole history of the case as given, it may be said, the doctor adds, that a month after this lesion had taken place all effects of this severe injury had passed away, except a slight puffy appearance about the face, a little clumsiness in his movements, and some irritability of temper. Since that time, he became as healthy and strong as ever he was. The patient was closely watched during the course of his illness, but the doctor

failed to detect any morbid mental manifestations that seemed to indicate injury to any distinct phrenological development.

It will be seen that no disturbance of functions took place commensurate with the injury, nor were they such as would be expected by the school of surface localizers.

In the Montreal Hospital Reports for 1879, we have two cases recorded. The first is a case of a wound inflicted by a swiftly-revolving circular wood-saw. It produced serious lesion in the central part of the first and second frontal convolutions on the left side. The skull wound extended in an oblique direction from above the outer angle of the left orbit across the frontal, through the anterior superior angle of the right parietal and terminated about the centre of this bone. It had penetrated through the membranes, and at the central part the brain substance was lacerated and exposed and could be seen pulsating. The *post mortem* revealed a large rent extending from the longitudinal sinus downward and outward to a point a little anterior to the beginning of the fissure of Silvius. The central portions of the first and second left frontal convolutions were completely destroyed. The patient was unconscious for about ten minutes after the accident, but when taken to the hospital became *quite conscious* and at that time had no paralysis; nor are we told that either one or the other supervened before death, which took place two days after the accident.

In the same Hospital Reports, the history of a second case is given: A young man, aged 22, was accidentally shot by the discharge of a pistol. The bullet entered the skull above and a little in front of the right ear. From the first he was perfectly conscious, *not paralyzed*, and gave a rational account of how it happened. A probe was inserted into the wound, and it passed freely into the frontal lobe in the course of the bullet. Pulse 60; no elevation of temperature. The accident happened March 8th, and he died of consumption, Aug. 12th following; but between these two periods there was no unusual mental disturbance. Without giving the details of the autopsy, suffice it to say, that the bullet entered the brain substance in the right inferior frontal convolution, just in front of the ascending branch of the Sylvian fissure. From this point the course of the bullet was upwards and forwards, passing out at the inner surface of the frontal lobe and lodging between the brain substance and the falx, where it lay surrounded by a firm membrane. A firm membranous canal marked the course of the bullet, and the brain substance about this was somewhat softened. This extensive destruction of brain tissue did not turb the mind.

M. Flourens, of Paris, some years ago, experimented on animals, not only to show the curability of brain substance, but also to demonstrate how much brain tissue can be injured without the untoward physical and mental results formerly apprehended and dreaded He trepanned the skulls of dogs and rabbits, made a small opening through the *dura mater* into the substance of the brain, and then put bullets into the wound. These bullets gradually penetrated through the cerebral matter by their own weight. When the ball was small, he found that the whole thickness of the lobe of the brain, or of the cerebellum, might be traversed by it without occasioning any symptom or disturbance of function. The fissure made by the passage of the ball remains for some time as a canal; it then closes up and cicatrizes. (*L'Union Med.*, 1863.)

Dr. Thomas Smith, Surgeon to St. Bartholomew's Hospital, London, gives, in the London *Lancet* of January last, an interesting case in which the patient made a good recovery without loss of mental or physical power. A man, 35 years of age, shot himself with a revolver through the head. The bullet passed in at one temple and out at the other. Half an hour after the accident the pupils were found to be natural, pulse feeble, and respiration natural. The patient was quite conscious, and answered questions correctly concerning his name, age, and address, and of his own accord. He was an educated man and spoke in German, but when addressed in either French or English he would reply in the corresponding language. He showed no signs of mental incapacity, nor was there any loss of motor power. He vomited a good deal at first, and at that time

blood and cerebral substance were forced from the wound in the right temple. For several days he became quite irritable and had a few delusions, but no functional deprivation. On the forty-third day after the wound was inflicted he became quite well. At first a probe was passed its whole length into the wound and across the head without meeting the slightest resistance. At first the special senses were very slightly impaired; but all recovered their tone before he left the hospital, except the sight which was slightly impaired. As regards the course of the bullet in this case, Dr. Smith says: It is certain, from the position of the apertures of entrance and exit, that it entered the outer surface of the anterior lobe of the brain, a little above the level of the highest part of the roof of the orbit, and that it emerged from the left anterior hemisphere at a spot rather further back and at a slightly higher level. From the large effusion of blood in both orbits, which so rapidly followed the injury, there is reason to believe that in its passage across the skull the bullet fractured the roof of both these cavities. From the free and persistent epistaxis, it is probable that the cribriform plate of the ethmoid, or some part of the roof of the nasal cavity was broken into, while there was evidence, from the symptoms, that the olfactory bulbs did not escape disturbance or injury. It may be said that there is no direct proof that the left hemisphere of the brain was wounded at all; that the bullet may have run over the roof of the left orbit and up the inside of the skull to its point of exit from the bone. The surgeon is sure, however, that the probe traversed without any sensation of resistance, both hemispheres, and one would think it impossible that a bullet of the size and weight indicated, after passing through one side of the skull, could have knocked a piece of bone clean out of the opposite side unless it impinged upon the inner surface of the bone in a direct line. As further proof, pulsation and respiratory movements were observed in the blood tumour over the aperture of exit, and these were so forcible as to indicate that the interior of the brain was in direct contact with the ecchymosis. It is certain that the part of the hemispheres that was damaged was the anterior frontal portion just above the orbits. Has this part any functional centre? If so, where is the evidence of its being necessary, seeing that both frontal lobes were injured seriously, without any immediate results in proportion to the lesion inflicted? Is this an organization put in more to fill up than to be of use to its neighbours? I had the impression Nature had no garret filled with useless furniture. Some functional centres must have been badly broken up by this destructive intruder.

About seventeen years ago I was called to visit a boy, aged 13, who had been kicked by a horse. A section of the skull was crushed in on the right side, near the median line, in the upper part of the frontal and parietal bones. One of the nine pieces fractured and detached from the surrounding bone had been driven into the substance of the brain, over an inch, in a perpendicular direction. The membranes were lacerated very much and brain substance, within a few grains of an ounce in weight, protruded through the wound much broken up, some of it hanging down upon his cheek. At the time I first saw him he was comatose. I extracted the bones, cut away the ragged edges of the membranes and the lacerated brain substance. Consciousness returned immediately. His temperature remained normal; his pulse did not rise at any time above 96. He did not lose a night's sleep nor a meal after the evening of the accident. No febrile symptoms intervened. There was no paralysis, nor perversion of any of the organs of special sense. There was no difficulty in speaking. A large cavity remained. He afterwards went to school to the same mistress as before, and she informed me that with the exception of a certain irritability of temper when thwarted (which he did not possess before), he was as intelligent as ever, and could learn his lessons with the usual aptitude. This was especially noticeable in mental arithmetical exercises. He was under my observation for several years after the accident. After he was aroused from his comatose condition, consequent on compression, his special senses were unimpaired; his loco-

motion and grasping power normal; and his bodily health good in every particular.

These examples might be indefinitely extended. Medical literature is full of evidences of destruction to the brain matter of the cerebrum and cerebellum without any serious impairment of mental power or physical functions. Let a brain be taken, and wires passed through it to indicate the course of the missiles in these cases I have mentioned, and it will be seen that brain substance has been injured in almost every conceivable direction, yet with no results at all commensurate with the lesions inflicted. If these parts are motor centres, then have we the miraculous phenomena of organic operations without an organ; of varied and distinct functions without a motive power; of uniform results without an efficient cause.

Were we even to consider the brain a dual organ the difficulty would remain, where corresponding sides are simultaneously injured. In all the dual organs of the body we find sudden injury to one is always followed by imperfect work in its fellow until time is given to allow provision to be made for the extra labour imposed. When we find no impairment in function consequent on destruction of *one* so called motor centre, we are led by uniform analogy to doubt a doctrine so anomalous and contradictory. At least, it is better to receive with caution a theory which is being accepted, based upon exceptional examples, which do not account for the physical results, except in isolated cases. The mental effects seen, as consequent upon brain injury, would prove too prolific a theme for present investigation.

Printed at the Guardian Office, 80 King Street East and 4 Court Street, Toronto.