Have we two brains or one?

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HAVE WE TWO BRAINS OR ONE?

I. Long ago, in Washington, Brooklyn, and New York, I delivered lectures—still unpublished—with the object of showing that each of the cerebral hemispheres is a complete brain, endowed with all the powers that we know belong to the whole cerebrum. I especially put forth, and will now try to establish, the idea that each half of the brain is capable of originating all the voluntary movements of both sides of the body, and possesses the powers of perception of the various sensitive impressions that may proceed from the whole body; so that, in the same manner that we have two eyes, two ears, etc., we also have two great nerve centres, each of which is capable of performing in its full extent every physical cerebral function.

When I brought forward that revolutionary view, it was in absolute opposition to the opinions held by all physiologists and physicians. But a great progress as regards the duality of the brain had already been accomplished respecting the mental faculties. Many years before my lectures, Dr. A. L. Wigan had issued his celebrated work on "The Duality of the Mind" (London, 1844), in which, after some eminent French writers—Pinel, P. Bérard, Bouillaud, and others—he had shown that in cases when a lesion has destroyed one of the cerebral hemispheres, all the mental faculties may remain quite normal. It is most remarkable, however, that a lesion occupying only a very small part of the brain, in almost any region, can either alter or destroy one or another of the mental faculties or all of them. In the same way, a small lesion can produce a diminution, or the loss, of one or of all the physical functions of the brain, while, on the contrary, as I will try to show, the most extensive lesion of one cerebral hemisphere, or of one half of the base of the brain, can exist without any loss of those functions. I need not say that such facts are quite decisive against the universally-admitted view that each half of the encephalon, as regards voluntary

movement and sensibility, serves only for the half of the body on the opposite side.

II. In an article on "Cerebral Localization" * I have already given a number of arguments against the prevailing doctrines relating to the mechanism of brain functions. Among the conclusions which I drew from the facts and reasonings contained in that paper, there are two which it is essential to reproduce: 1. Nerve cells endowed with any of the cerebral functions, instead of forming a kind of cluster, as is supposed, are disseminated through the whole encephalon, so that considerable alterations or destructive lesions can exist in one of the cerebral hemispheres, or in both, without the loss of voluntary movements, of sensibility, or of any other brain function. 2. The complete disappearance of any cerebral function, in cases of organic brain lesion, is due to a suppressing influence exerted on all the nerve-cells that have a share in that function, in either the encephalon or the spinal cord. The mechanism of that disappearance is that of inhibition, such as takes place in the heart when the activity of that organ is stopped by an irritation of more or less distant parts.

III. The differences which are frequently found between vertebrate animals and man, are now justly considered as being generally mere differences in degree and not in kind. It is quite legitimate, therefore, to apply to man most of the results obtained from experiments on those animals. It is perfectly known and fully recognized by all physiologists that, in the scale of animals, from frog to man, new parts are gradually added to the nervous centres; that, consequently, certain functions of the nervous centres gain more and more power; and that new functions supervene which had no existence in animals compared to man, or in the higher groups of animals compared to the lower ones. Our purpose, therefore, is to make use discriminately of the results of experiments on animals, and to ask from a frog what it can give, and not what can be obtained only from animals placed much higher in the scale.

IV. The grounds for the views relating to the cerebral duality which are generally admitted, are the following: 1. That an irritation of parts of one half of the brain causes movement in

* FORUM, April, 1888.

the opposite side of the body. 2. That paralysis and anæsthesia appear always on the side opposite to that of a brain lesion. 3. That when a lesion has lasted some time in the so-called motor track of the encephalon, on one side, a secondary degeneration is found which indicates that the channels of an order of the will to muscles pass to the opposite side of the body. I will now proceed to the examination of these various arguments, and at the same time will show that facts which are in harmony with the admitted doctrines can be, and ought to be, explained in quite a different way. I will, besides, try to establish that those facts, as well as a great many others, together with many arguments in opposition to those doctrines, all give support to the views I have proposed.

V. It is well known that certain parts of one side of the surface of the brain can, when excited by galvanism, in mammals, give rise to movements in the limbs, face, eye, and trunk, on the opposite side. Those parts are called psycho-motor centers, and they are looked upon as acting on muscles by nerve currents descending to the crus cerebri, the pons Varolii, and the anterior pyramid on the same side, passing, where the pyramids decussate, into the posterior part of the lateral column of the spinal cord on the other side. That this view must be rejected, is clearly proved by the following facts.

After having ascertained what degree of galvanic power can produce certain movements in the limbs, face, etc., on the side opposite to that of the psycho-motor centers which I irritate, I divide transversely either half of the pons Varolii, or of the medulla oblongata including the anterior pyramid, or the crus cerebri, on the side of the galvanization. I then apply again the same galvanic current to those pretended motor centers, and I find that, although the only supposed channels of communication between the brain on the excited side and the muscles on the opposite side, are divided, the action of galvanism is greater, as the movements are more energetic. If the doctrines which are admitted were true, no movement at all could then be produced.

In other experiments, I have ascertained that after the section of both anterior pyramids, the two so-called motor centers can act so as to cause movements almost as well as when the whole

nervous apparatus is normal, which clearly shows that the pyramids are not the only, and not even the principal, channels by which irritations applied to the supposed motor cerebral zone are transmitted to muscles.

In experiments, which for lack of space I cannot describe, I have ascertained that the effects of an irritation of the various parts of the base of the brain cannot, in the least, serve to establish what is the place of passage of ordinary voluntary motor impulses in those parts. All of them produce, in most instances, movements in the corresponding, and not—as should be—in the opposite, side, even when the part irritated is the anterior pyramid just above the spot where its fibers pass into the other side. Still more, if I divide transversely the anterior pyramid, or the whole lateral half of either the medulla oblongata or the pons Varolii, and then irritate one or the other of the two surfaces of the section, *i. e.*, the one yet in normal connection with the brain or the other normally united with the spinal cord, the same movements appear almost always on the side of the irritation, showing that in both cases a reflex action of the uninjured side of the brain is produced. I ought to say that a mechanical irritation causes the same effects as a galvanic one, so that it cannot be supposed that it is owing to a diffusion of a galvanic current that these curious phenomena occur. In presence of such facts, we can certainly state that nothing remains of one of the most important foundations of the doctrine that the motor nerve fibers of one side of the body proceed exclusively from the other side of the brain.

VI. An argument similar to the preceding has been employed by clinicians to show that one side of the brain must be the mover of the opposite side of the body; it is the frequency of convulsions in the limbs or face on the side opposite to that of a lesion of the psycho-motor centers. The question should have been enlarged and put as follows: What are the relations between the various parts of one of the cerebral hemispheres and unilateral convulsions? In a paper I read at the meeting of the British Medical Association, at Cambridge, England, in 1880, I gave a number of conclusions drawn from more than 500 cases of unilateral convulsions due to brain disease, showing how various

these cases were as regards the seat of the lesion which caused these manifestations, the muscles attacked, and the connection of this symptom with paralysis and other phenomena. Among other things I showed, 1, that convulsions can appear on the hemiplegic side, or on the other, whatever be the seat of the lesion; 2, that if unilateral convulsions from disease of one side of the surface of the brain appear far more frequently on the opposite side of the body, they occur, on the contrary, more often on the corresponding side of the body when they are caused by disease of the base of the brain. It is clear, from these general data and from many others, that convulsions cannot be considered as supporting the view that each cerebral hemisphere contains the only centers and conductors for the voluntary movements in the opposite side of the body.

VII. Facts abound, relating to paralysis, or to its absence, in cases of organic lesion of the brain, which show that the views held by most medical men as regards the mechanism of production of paralysis, and its meaning concerning the duality of the brain, are absolutely untenable. Paralysis from brain disease having been used as the most powerful means of support for the doctrine that each of the cerebral hemispheres exclusively contains the centers for the voluntary movements of the opposite side of the body, it is essential, for the object of this article, to prove that this cessation of the power of motion does not depend, as is supposed, on the loss of a motor function of the part organically altered or destroyed, but, on the contrary, that it is due, as I have tried to show already in the FORUM,* to a peculiar dynamical influence (inhibition), exerted on motor nerve cells disseminated in many parts of the nervous centers. I have then to show that it is not the part where an organic lesion exists which loses the motor power that disappears, but more or less distant nervous elements, dynamically affected.

VIII. The first argument I shall employ comes from a very interesting experiment on frogs. It is known that when both cerebral lobes are taken away from these animals, no paralysis appears. I have found, however, that when one of those lobes is cut transversely, hemiplegia is caused immediately on the op-

* April, 1888.

posite side, just as would be the case in man from an analogous lesion. If, then, I divide, at the same level and transversely also, the other cerebral lobe, the paralysis produced by the first operation disappears, and the frog seems to move all its limbs just as well as if nothing had been done to the brain. What takes place in those experiments is that the first lesion produces a dynamical change in the nervous centers, one side losing, and the other gaining, power; and that the second lesion re-establishes the dynamical equilibrium, in giving force to the paralyzed side and diminishing the energy of the abnormally strong side. In that case we have an absolutely clear demonstration that paralysis can appear from a mere dynamical influence exerted on more or less distant parts (chiefly the spinal cord, in this instance) by an irritation of a part of the brain.

IX. On many guinea-pigs, rabbits, and other animals, I found that if, after a cerebral injury, paralysis had appeared on one side, I could, by certain other injuries, make that diminution or loss of motor power disappear, in a marked degree if not completely, and produce a paralysis elsewhere. It is clear that such could not be the case if it were by a destruction of a motor function belonging to the part first injured that paralysis shows itself after certain brain lesions. It is clear, also, that a mere dynamical change alone can explain the sudden disappearance of paralysis from the place where it first had been caused. A transfer of paralysis due to a second organic lesion, as in those experiments, has been observed in man by Prof. Leyden and Dr. Dowse.

X. The doctrine generally received by clinicians, and according to which the conductors of the orders of the will to muscles decussate at the spinal end of the anterior pyramids, is proved to be quite false by experimental facts. As that decussation exists in other mammals as well as in man, the same effect should be produced in them as in man, after the section or a destructive lesion of one side of the medulla oblongata, including the anterior pyramid. But it is not so; in other mammals the paralysis is almost always on the side corresponding to that of the injury, while in man it is on the opposite side. In certain mammals, the transversal section of a lateral half of the pons Varolii will give rise to a cross paralysis, while in others this lesion will

cause a direct paralysis; and, to obtain a cross one, we must divide a part higher up than the pons—the crus cerebri. As the anatomical organization of the base of the brain is essentially the same in man and in all those mammals, it is evident that if a cross paralysis in one case depended on the section of certain fibers, a similar effect should occur also in the other cases in which the same fibers exist, and we should not see a direct paralysis. If possible, what I have seen in cats is still more decisive. In very young ones, after the section of one of the crura cerebri, paralysis usually appears on the corresponding side, while in adults it comes on the opposite side.

We can legitimately conclude from those various facts that paralysis, in such instances, does not depend on the loss of a motor function belonging to the injured parts, as otherwise in all those cases the paralysis should have been a cross one, the decussating fibers of the anterior pyramids having been divided in all of them. This variety of effects is in perfect harmony with what we know of purely dynamical results from an irritation, and it shows that, at least in those cases, paralysis is not due to the loss of a supposed function of the part injured, but that it is a consequence of an irritation that acts on distant parts.

XI. One of the best arguments against the views that paralysis depends on the fact that the lesion with which it is allied has destroyed parts having a motor function, is to be found in cases of direct paralysis. I can say that most clinicians having had for years a large practice have seen such cases. I have seen several; and in one of them I made the autopsy of the patient at the *Charité* Hospital, of Paris, in presence of my able master, Dr. Rayer, and with the help of Dr. Tailhé and Prof. Lebert. In another case, that of a patient who consulted me at Cambridge, Mass., I diagnosed the presence of a tumor at the base of the brain on the side of the paralysis, and this was confirmed by the autopsy, made long afterward by Dr. Edes, of Boston.

Every part of the brain and every kind of lesion can produce a direct paralysis. Of the well-known medical observers who have seen it, I will name only, among the French, Andral, Bayle, Bourneville, Cruveilhier, Dechambre, Gintrac, Gubler, Hayem, Jaccoud, Baron Larrey, Rochoux, Rostan, Trousseau, Valleix,

Vulpian; among the English, Abercrombie, R. Bright, Bristowe, Callender, Cheyne, H. Day, J. Hughlings Jackson, J. W. Ogle, Ramskill, Sharkey, Stanley, Toynbee, Sam Wilks; among the Germans and Austrians, Albers, Arnold, Drozda, Foerster, Lebert, Nasse, Petrina, Virchow, Wenzel; among the Americans, Drs. Horner, of Philadelphia, Enos, of New York, Abbot, Edes, Gould, Homans, Wellington, of Boston.

An effort has been made to escape the verdict of those facts. It has been supposed by Longet, Hilton, and other writers, that the direct paralysis is due to the absence of the decussation of the anterior pyramids. But it happens that decussation existed in the only three cases of that kind of paralysis in which an examination was made of the anatomical condition of the pyramids. Those cases were published by Drs. E. H. Dickinson, Blaise, and Féré and Arnould, whose papers I have quoted in an article on this subject.* Among the arguments I made use of in that paper, with regard to the value of the decussation of the pyramids, I showed that, while that crossing is not known ever to have been missing in any case of direct paralysis, this kind of loss of movement is extremely frequent when disease is located in certain parts of the brain. Indeed, according to a statistical account I have made of cases where unilateral lesion in the medulla oblongata has given rise to hemiplegia, this loss of motion appeared on the side of the lesion in one half of those cases. If now we compare to that proportion that which exists in cases of disease of the so-called motor zone of the cerebral surface, we find that the proportion of cases of direct paralysis is less than one out of a thousand cases of unilateral paralysis. The only explanation of the excessive frequency of direct paralysis in cases of a lesion of the medulla oblongata, and its far more excessive rarity in cases of disease of the so-called motor centers, would consist in this most absurd supposition—that a lesion appears very much more easily in the medulla oblongata when it attacks persons (if there are such) who have no decussation of the anterior pyramids, while it occurs in the motor zone of the cerebral convolutions when it attacks persons having a decussation. If space permitted, I could show that the variations in the number

*See the "*Archives de Physiologie Normale et Pathol.*" Paris, 1889.

of the decussating fibres of the pyramids, which we know from Flechsig's researches to be very great, is in absolute opposition to the view that those fibers are the only or the principal conductors of voluntary motor impulses, and that they have, therefore, nothing to do with the existence of direct or cross paralysis.

XII. According to the generally-admitted views, paralysis, in cases of brain disease, should appear only when a lesion exists in certain parts considered as forming exclusively the supposed motor centers and track. I can state, however, that there is on record a very large number of cases where paralysis has been caused by an injury or a disease located very far from those centers and track. Among those parts of the brain which have caused a loss of voluntary movement when there should have been none, I will especially point out the extreme ends of the cerebrum and most parts of the cerebellum. In the cases I have collected, I have carefully avoided those in which a pressure could have existed on so-called motor parts. Out of the many papers I have published containing such cases, I call attention only to one of my lectures in the "Lancet" for August and September, 1876.

XIII. Paralysis depends so clearly on an irritation of brain tissue, and not on the destruction of conductors or centers endowed with the function which disappears, that, as I have shown in 1879, in 125 out of 181 cases of tumor pressing on one side of a certain part (and always the same) of the base of the brain, there was the excessive variety of paralytic manifestations exhibited in the following table:

1.	Paralysis of the two limbs on the side of the lesion,	37 cases
2.	" " one arm " " " "	3 "
3.	" " " leg " " " "	1 "
4.	" " the two limbs on the opposite side,	21 "
5.	" " one arm " " "	8 "
6.	" " " leg " " "	4 "
7.	" " the two lower limbs (paraplegia),	23 "
8.	" " " " upper " (brachial diplegia),	1 "
9.	" " one arm in one side and leg in the other,	1 "
10.	" " three limbs,	4 "
11.	" first of the limbs on side tumor, then of other limbs,	2 "
12.	" of the four limbs,	20 "

Besides showing a greater frequency of direct than of cross

paralysis, this table gives a pretty large proportion of cases of paralysis of the two lower limbs (23 out of 125). This kind of paralysis, *i.e.*, paraplegia, may be due also to unilateral lesions in a great many other parts of the brain. I am fully aware that, out of more than 70 such cases that I have collected, a great many should not be counted, as the state of the spinal cord had not been ascertained. Still, even in these cases, the symptoms pointed to the brain as having caused the paraplegia. But in a number of cases the spinal cord, being examined, was found healthy, and, therefore, there is no possibility of denying that one side of the encephalon can produce paralysis in both lower limbs, *i. e.*, a direct paralysis and a cross one. The above table shows most decisively that paralysis may appear in one place or another, although due to a lesion in the same part, and that, therefore, it cannot be considered as allied with a loss of function of the injured part.

XIV. The most decisive argument against the view that we have but one brain for voluntary movements, comes from cases of destruction, in man as well as in animals, of some parts of the supposed motor centers or conductors, or of almost the whole and even the whole of a hemisphere, without paralysis.

It is perfectly well known that, excepting in animals highly placed in the scale of mammalia, we can take away a lateral half of the brain without producing a persistent paralysis. It is, of course, manifest in such a case that all the voluntary movements of the two sides of the body can be performed by one half of the brain. As regards man, facts abound showing that destruction of every individual part of one hemisphere can take place without the disappearance of the voluntary motor functions. Leaving aside cases of tumors or abscesses, there are on record, to my knowledge, more than fifty well-authenticated cases of considerable lesion or complete destruction of the so-called psycho-motor centers on one side, without paralysis. A good many of the authors to whom we owe those facts are men of high standing, and some are physicians of real eminence. Among the best known I will name Vulpian, R. Bright, Andral, Fürstner, Murchison, Longmore, Poncet, H. Day, Luys, Magnan, Duplay, R. Boyd, De Fleury, König, Lecorché, Campbell, R. Quain.

In presence of such facts, a number of able clinicians, without, however, coming frankly to the view that I hold, have tried to explain them by supposing that some other parts of the brain can take up the function of the diseased organ and act in its place. With regard to this, two suppositions have been made. According to one, this replacement occurs in the same side where the lesion exists, and according to the other, it is performed by parts of the opposite side of the brain. This second supposition is in direct opposition to numerous facts showing that a complete destruction of the so-called psycho-motor centers on the two sides can take place without the disappearance of the voluntary movements anywhere. I have collected and published a good many facts establishing this point, and I will mention the following authors as the best-known among those who have seen such cases: Billard, Marcé and Luys (two cases), Siredey, Parchappe, J. Hutchinson, Bouillaud, Gama, Sims, Gintrac, Wernicke, Fürstner, Broca, R. Bright, Poumeau, Brière, Lenormand, Abercrombie.

Pursuing our demonstration, if we examine what occurs as regards the parietal lobe of the brain alone, or the posterior part of the frontal lobe, we find that there are a great many cases of destruction of these middle portions of the cerebrum—which are looked upon as absolutely essential for voluntary movements —without paralysis supervening. Among the observers to whom we owe those cases, I will name Prévost and Cotard, R. Bright, J. G. Forbes, Warren, Guérard, Bossu, Lagout, Gintrac, Fowler, W. Jones, T. Byrant, Oulmont, Montault, Girard, T. Thompson, A. B. Duffin, Porral, O'Hallaran, C. Holthouse, Dumon.

Before reaching the base of the brain, the fibers establishing a communication between it and the cerebrum are chiefly, if not entirely, congregated in the internal capsule. It is evident, therefore, that a destructive lesion of that part alone, or with the corpus striatum and the optic thalamus, must be the cause of a complete paralysis on the opposite side of the body, if the reigning doctrine on cerebral duality is right. It is not so always, however, as shown by a number of cases published by Gintrac, Lagardelle, J. Russell, and Delbet. I have decided not to make use of cases of tumor, on account of the fact that the fibers and

cells of the brain may remain partly able to act although considerably squeezed. Still, I am entitled to employ cases in which there was a real destruction of the internal capsule by a tumor. There was no paralysis in some such cases published by B. Ball, A. Denmark, Barié, Mueller, and W. B. Hadden.

I come now to the base of the brain, a part which gives a large proportion of cases of destructive lesion without paralysis. Among the authors who have given such facts with regard to the crus cerebri, I will name only the best-known. They are: Sander, Elam, Callender, J. Hughlings Jackson, Hayem, Stiebel, H. Roe, J.W. Ogle, Squire, Reynaud-Lacroze, Leboucher, Raikem, Abercrombie, E. A. Parkes, Landouzy, J. B. S. Jackson. As regards the pons Varolii, a destruction of a great part of one of its lateral halves, including the whole of the supposed motor track, has frequently been recorded in cases with a very slight paralysis, or none at all. The following are the best-known among the observers to whom we owe such cases: F. Mason, C. Mills, Broadbent, Gay, Moutard-Martin, Raikem, J. R. Bennett, Van der Byl. Regarding the medulla oblongata, I will name also the most prominent observers. They are: Vulpian, Cruveilhier, Raikem, Martineau, Taylor, J. Johnson, Middleton, Michel, Royer-Collard.

It is evident from all these cases that one half of the base of the brain is quite sufficient to convey to the muscles of the two sides of the body the orders of the will coming from either one or the other of the two cerebral hemispheres.

The facts remaining to be mentioned are among the most powerful to show that one half of the brain can originate all the voluntary movements of the two sides of the body. They consist of cases of considerable alteration, if not of destruction, of a whole cerebral hemisphere, without paralysis, or with only a slight paresis. I will mention among the observers who have published such cases, the following: Belcher, Tacheron, Serres, Abercrombie, Monod, G. Lowther, Cless, Guéneau de Mussy, Rendtorf, H. Greenhow, Porta, Th. Bryant, Rendu, Debierre, Lélut, McReady, Alègre, Hayem.

XV. I could bring forward many other facts showing, like those I have mentioned, that paralysis can appear where it should

not, or may not appear at all, in cases of a lesion which should always produce it in certain parts of the body, according to the generally-admitted views. But it does not seem necessary to say more on these points, as I believe that what precedes is quite sufficient to establish that each half of the brain can originate all the voluntary movements of the two sides of the body, and, therefore, that we have two brains for all the muscular actions caused by our will in the four limbs, and other parts of the body.

XVI. Arguments similar to those concerning the voluntary movements exist also as regards the transmission and the perception of sensitive impressions. They give forcible proofs that one cerebral hemisphere may be quite sufficient for the perception of all the impressions coming from the various parts of the two sides of the body. I will mention only some of the most striking arguments relating to this part of my subject.

The following experiments furnish the best of these arguments. I discovered long ago that very frequently, after a section of a lateral half of the base of the brain, on a mammal, anæsthesia appears on the opposite side of the body and hyperæsthesia on the corresponding side. If on an animal having had such a section on the right side, and having become anæsthetic in the left side of its body and hyperæsthetic in the right side, I divide the left lateral half of the dorsal spinal cord, I obtain this most remarkable result: the left abdominal limb not only recovers sensibility, but becomes hyperæsthetic, and the right one loses its sensibility. It is evident that if the anæsthesia in the left abdominal limb were produced by the first lesion (that made at the base of the brain), owing to a section of the conductors of the sensitive impressions coming from that limb, the second lesion (made on the dorsal spinal cord) could not have modified sensibility in any way in that part. It is quite certain that the anæsthesia which appeared in the left hind limb after the first lesion was due to a mere dynamical influence, as it disappeared immediately after the second lesion.

An experiment of Dr. Veyssière had led him to look upon the posterior part of the internal capsule as the place of passage of conductors of sensitive impressions in the brain. This view was admitted by most physiologists, and was soon strongly sup-

ported by physicians, who showed that in many cases of disease of that part in man there had been a complete loss of feeling in limbs, trunk, and face on the opposite side of the body. Facts of that kind would be in radical opposition to the view I propose concerning the duality of the brain, if it were true that we are to explain that loss of sensibility by admitting that the section or destruction of the posterior part of the internal capsule interrupts all communications between the center of perception and the half of the body which becomes anæsthetic. The following experiment will show conclusively that this is not true.

After having made Veyssière's experiment, and ascertained, as he had done, that anæthesia is caused on the side opposite to that of the operation, I divide the lateral half of the dorsal spinal cord on the anæsthetic side, and I find that sensibility not only returns in the hind limb on that side, but becomes greater than in the normal state. It is evident, therefore, that it was not owing to the section of supposed exclusive conductors for the transmission of sensitive impressions that there was anæsthesia after the first operation in this case.

If anæsthesia in one half of the body has been produced by the extirpation of the pretended centers of perception of sensitive impressions, as Prof. Schäfer, V. Horsley, and others have shown to be the case, it disappears also and is replaced by hyperæsthesia in the hind limb, as I have found, after the division of the lateral half of the dorsal spinal cord on the side where it existed. In this case, as in the preceding, it is evident that it was not absence of a part of the nervous center which was the cause of the loss of feeling.

Clinical facts like these experiments show that it is not because a diseased part is endowed with the function of perception, or of transmission of sensitive impressions, that anæsthesia appears when a lesion exists in one half of the brain. It is produced by an irritation which starts from the neighborhood of the destroyed tissue, and proceeds to more or less distant elements scattered in the nervous centers, inhibiting their function. I believe that I have proved in a number of papers the correctness of these conclusions, but I will especially refer to my last publication, which appeared in the "*Comptes Rendus de la Société de*

Biologie" for 1888. I will say here only that arguments similar to those I have employed in this article, concerning voluntary movements, exist also as regards sensibility. A great many facts show that anæsthesia, like paralysis, in cases of unilateral lesion, can appear; first, on the corresponding side, and the more frequently the nearer the injury is to the medulla oblongata, and, therefore, the farther from the top surface of the brain; secondly, in the two lower or the two upper limbs; thirdly, in three limbs, or in all four. Like paralysis, anæsthesia also can appear in one side only of the body from lesions occupying the same extent of the base of the brain on the two sides of the middle line; it can, besides, show itself in cases of lesion in any part of the brain, even one not supposed to be employed as conductor or center for sensitive impressions.

One of the strongest arguments against the received views, and in support of the idea that one side of the encephalon is quite sufficient for the transmission and perception of the sensitive impressions coming from the two halves of the body, is that sensibility can persist entire, notwithstanding the destruction of any part of one half of the brain. I cannot enter here into the details of the cases establishing the correctness of this statement. I will only make a few remarks about some of the facts.

The center of perception of sensitive impressions has been placed in very different parts of the brain. Chiefly from experiments on monkeys, Schäfer, Horsley, and others have supposed that the seat of that power is the limbic lobe. The fact I have already mentioned, that if the extirpation of that part has caused anæsthesia, a section of a lateral half of the cord will make sensibility reappear, disposes of that supposition. Clinical facts show also that the limbic lobe can be destroyed without any loss of feeling. A talented New York physician, Dr. Charles L. Dana, published two years ago an excellent paper, in which may be found several such cases, to which I could add a number of others. Other physicians place the perceptive power in the convolutions where are localized the psycho-motor centers. In a great many cases, however, these parts have been destroyed without any loss of feeling or paralysis.

Cases of considerable alteration of a whole cerebral hemi-

sphere, or of all the parts establishing a communication with the base of the encephalon, without any diminution of sensibility or any marked degree of anæsthesia, have been published by Andral, Bouchut, Barthez, Beau, Anger, Gintrac, Porta, Richet, Robertson, Lallemand, and others.

As regards the base of the brain, I know of more than forty cases of considerable alteration or complete destruction of one or the other of the three parts composing it—one crus cerebri or one side of the pons or medulla—without anæsthesia. It is certain, therefore, that the channels of transmission, as well as all centers of perception of sensitive impression, can be destroyed in one half of the encephalon without anæsthesia. And this clearly shows that one half of that great nervous center is quite sufficient for the performance of all functions relating to sensibility in both sides of the body.

XVII. Before concluding, it is necessary to show that physicians, and also certain physiologists, who look upon the secondary or descending degeneration, often seen in cases of disease of the brain, as having the utmost importance with regard to its duality, would have to change their minds if they paid attention to the following facts. It is known that such degeneration descends from the seat of a lesion in one half of the brain to the place of intersection of the anterior pyramids, and there passes from one side of the encephalon into the posterior part of the lateral column of the spinal cord, descending to the lumbar end of the spinal center. That the fibers which degenerate in such cases are not, as is supposed, the only or the principal channels of transmission of the orders of the will to muscles, is evident. 1. Cases of degeneration of the anterior pyramids and other parts, without paralysis, have been recorded by Bouchard, Albers, Fürstner and Zacher, Lange, Partridge, Debierre, W. B. Hadden and C. S. Sherrington, Bryson Delavan, Landouzy, Lancereaux, Barié, Luys, and others (I must say that, in those cases, the absence of paralysis is made more decisive by the fact that, besides the degeneration of the base of the brain and the lateral column of the cord, there was a persistence in the brain of the lesion which had given origin to the degeneration). 2. The secondary or descending alteration, instead of being, as it

should, a continuous one, may show itself in one part and not in the next, as evidenced by cases of Landouzy, Lépine, Lélut, Hanot, Vulpian, Bourneville, Védie, and others. 3. The secondary degeneration may not appear, however great and persistent may be a brain lesion giving rise to paralysis. 4. The part of the spinal cord which is altered in a descending degeneration is hardly a motor part.

XVIII. That we have more brain matter than is needed, is clearly proved by the facts and reasonings contained in this paper. This is shown also by a great many cases in which a considerable destruction of cerebral tissue, on the two sides, has occurred without any loss to either the physical or the mental functions of the brain. Not only can half of the encephalon carry on all the functions known to belong to the whole brain, but there are cases of almost complete destruction of one side and also of a part of the other side of the brain, without either an alteration of the mental powers or the loss of the physical faculties of that great nervous center.

In connection with the subject of the duality of the brain, there is one point of great importance about which I can say only a few words. It is that we have a great many motor elements in our brain and our spinal cord which we neglect absolutely to educate. Such is the case particularly with the elements which serve for the movements of the left hand. Perhaps fathers and mothers will be more ready to develop the natural powers of the left hand of a child, giving it thereby two powerful hands, if they believe, as I do, that the condition of the brain and spinal cord would improve if all their motor and sensitive elements were fully exercised.

C. E. Brown-Séquard.

THE FUTURE OF FICTION.

It might well seem a foolhardy venture to attempt to forecast the future of fiction. How, it may be asked, are we to gauge the artistic value and the possibilities of growth of so voluminous and chaotic a material as the contemporary novel? It is questioned by some whether prose fiction has any rightful place in the world of art, and many who would hardly go so far as this in the path of skeptical doubt maintain that the larger part of recent fiction is of no real and permanent worth. On the other hand, there seem to be some happily-constituted persons who discern in the abundance of recent literary output a proof of the prodigality of Nature, who has somehow managed in these latter days to produce something like a plethora of literary genius.

In view of such a perplexing state of things, all that one can hope to do in the way of conjectural forecast is to seek for indications of the future destiny of the novel in a clearer conception of its origin and essential art function. If we can manage to throw a ray of light on the origin and *raison d'être* of the novel, we shall be as advantageously placed as it seems possible to be for answering the question whether it still has a future, and if so, what sort of one.

And here it seems necessary, by way of introduction, to say a word or two respecting the function of art in general. This may doubtless look alarming, suggestive of baffled wanderings among metaphysical subtleties. But let not the reader be afraid. I propose in these pages to spare him everything in the shape of disquisition on the nature of beauty, and merely to call his attention to one or two characteristics of art which have come of late to be more and more clearly recognized.

The first of these characteristics is its play aspect. By this I mean that art, like play, offers us a pleasurable vent or outlet for redundant energy. This idea is as old as Aristotle, though it