The relation of brain to mind : a lecture delivered to the Dialectic Society of the University of Glasgow / by John Cleland, M.D., D.Sc., F.R.S., Professor of Anatomy.

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THE RELATION OF

BRAIN TO MIND:

A LECTURE DELIVERED TO THE DIALECTIC SOCIETY OF THE UNIVERSITY OF GLASGOW.

BY

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THE word Life is liable to be used in more senses than one—sometimes indicating mere activity of any sort, sometimes intelligence, and sometimes moral aspiration ; though none of these is its proper sense. Like other words, its explicitness has suffered from the imperfection of our knowledge in times past of the thing indicated by it. We used to distinguish vegetable from animal life, and with animal life were, in consequence perhaps, liable to confuse indications of consciousness. But now we recognise life as a feature common to animals and vegetables, and a thing of the same description in both. *Life is the capability of undergoing that series of actions by which an individual is not only maintained but likewise determinately changed or developed by the attraction and disposal of particles drawn in from without and the extrusion*

of others. I think that even reproduction may be considered as included in that definition, and the definition states things common to plants and animals.

Be it understood that *the vast majority of both plants and animals are compound*, consisting of innumerable microscopic individuals, or living corpuscles, to each of which the definition applies. Each of these microscopic units or living corpuscles is composed chemically of an exceedingly complex substance, a substance far exceeding in chemical complexity anything found in the inorganic world, a substance of which chemists have not arrived at a thoroughly explicit knowledge, and which assuredly is not exactly the same in every living part of every living being, but yet may always be classified under the name of albuminoid matter, and in many of its varieties is termed, vaguely enough, *protoplasm.*

No vital function is ever performed except by corpuscles which consist of albuminoid matter, and have in their early life consisted of the description known as protoplasm. And it is worth while to pause for a moment to note that while there are enormous numbers of organic substances filling up the grada-

tions of complexity between protoplasm and the simpler compounds of the inorganic world, not one of them occurs native, save as a product of life, and therefore a product of pre-existent protoplasm. Hence it follows that the numerous believers at the present day in the antiquated notion of the evolution of life from dead matter are placed in this dilemma :—either they must admit that protoplasm, in the first instance, had its origin in other than the ordinary operations of inorganic nature, by a sudden spring from inorganic compounds, totally at variance with the whole notion of an evolution; or they must be content to imagine an immense series of operations in days gone by, altogether different from anything that takes place now, whereby simpler organic substances were formed first and protoplasm was formed out of them.

However, the sum of all this to those of you who are unacquainted with biology is simply the universally acknowledged fact that life, both in animals and vegetables, is carried on by living corpuscles, which are microscopic masses of protoplasm, or some closely allied derivative.

The vital functions are nutrition (including repro-

duction) and irritability. Of nutrition I shall not speak at present; but to irritability I must direct your attention.

Irritability is the susceptibility of a living corpuscle to undergo physical change in consequence of a stimulus applied. The change may be of many different kinds. It may be evinced by an alteration of form, as in the contraction of muscles; by pouring forth some fluid, as in secreting glands; or by light, or an electric shock, as in the phosphorescence of many invertebrates and the electric organs of certain fishes. Also, it may result in the transmission of a change similar to itself to another part which in turn evinces it in some one of the ways mentioned; and that is what occurs all over the nervous system, and is technically known as the conveyance of an impression.

In animals all but the lowest, certain living corpuscles are set aside in their adult condition for the exercise of irritability, in one form or other, in an exalted degree, while they lose the reproductive power. Thus, as regards muscle and nerve, both of which in their healthy adult state cease to exhibit reproductive power; in response to irritation the

muscles contract, and nerves undergo a change which does not, indeed, result in any ascertained alteration of form, but is indicated by electric phenomena very similar to those which occur in an irritated muscle, and transmits its influence from one part to another.

A nervous system is primarily an apparatus by means of which irritations at the surface of the body are transmitted to a centre, and thence distributed so as to lead to combined action of muscular, glandular or other arrangements. So far as is at present known, it has no constant connection with anything of the nature of consciousness; nor for its completeness as a physical mechanism does it seem necessary that it should. In its simplest form, a nervous system consists of nerve-terminations on the surface, which receive the stimulus, mechanical or other, from without, and a nerve-centre united by nerves, not only with those terminations, but with other structures such as muscles. The mode in which this apparatus works is called reflex action: in which an uninterrupted series of physical changes can be traced, beginning with the application of the stimulus which affects the afferent nerve; while the afferent nerve affects the

nerve-centre, and the nerve-centre in turn affects the efferent nerve, which finally excites muscles, glands, or other organs to activity.

In all vertebrate animals by far the most important nerve-centre is what we call the cerebro-spinal axis, and divide for convenience into brain and spinal cord. I say that we so divide it for convenience, as it is important distinctly to understand that these two parts—the brain and spinal cord—form one continuous organ. Indeed, as it happens, they are indistinguishable one from the other in the lowest vertebrate animal, the amphioxus; and in earliest development in our own bodies they form one continuous ribbon. But the brain is so different in its later development that the difficulty in the adult, which the student experiences, is to see how it can be at all compared with the cord.

Now, when by means of an injury the cord, or part of it, is severed from connection with the brain, as sometimes happens when a man falls and breaks his backbone, the divided part of the cord, with the nerves belonging to it, makes an independent nervous system in which reflex actions not only take place but flourish, no longer repressed by the dictates of

consciousness, neither, indeed, affecting nor affected by it. Also, the brain has, like the cord, motor and sensory nerves connected with it, and is the centre, like it, of many purely reflex actions. It appears then that the brain is not only one in development with the spinal cord, but that it resembles it and every other nerve-centre known in having functions of a purely physical description excited by physical stimuli, and resulting in physical effects.

These being universally acknowledged facts, it is a most noteworthy circumstance that in all animals which exhibit tokens of intelligence those tokens are exhibited in connection with the nervous system, and that, in all animals with a brain and spinal cord, they are specially exhibited in connection with the brain ; while in at least birds and mammals it is beyond all possibility of doubt that there is no consciousness whatever in the spinal cord after it is severed from the brain.

Experiment shows that in at least birds and mammals there can be none of the higher operations of consciousness, nothing which can properly be called intelligence, apart from that particular portion of the brain which is called the cerebral hemispheres. These

hemispheres are an integral part of the brain, consisting of two hollow outgrowths comparable with other hollow outgrowths in connection with sight and smell. Their walls are of structure fundamentally the same as that of any other part of the cerebro-spinal axis, although, undoubtedly, they have arrangements in detail peculiar to themselves.

In the majority of fishes the cerebral hemispheres are very minute; in sharks and their kindred they are larger. In amphibians and reptiles they are more developed, increasing in size as we pass to the higher reptiles. In birds they have a larger development and a different character; and in mammals they arrive at enormously greater magnitude and complexity, increasing in both of these respects as we pass from the less to the more intelligent, and from those whose congeners were the first to appear on the face of the earth to those which have appeared last.

It is beyond contradiction that in the lower animals intelligence is developed *pari passu* with the cerebral hemispheres, and that, on comparison of the different races of humanity, the more intelligent races are found to have hemispheres of superior complexity to those of the less intelligent races.

In all this there is evidence that the cerebral hemispheres are in at least some sense the organ of the mind; and we find proof of a still closer connection than I have yet asserted, when we consider some physiological points. When the irritability of a living structure is stimulated, there is good reason to believe that in every instance there is a consumption of fuel; that is to say that the active condition, the contraction or effort to contract in the case of muscle, the analogous condition in the case of nerve, is induced and maintained by the oxidation of a certain amount of substance which is not, however, or at least is not necessarily, the proper substance of the structure itself. The proof of this in the case of muscle is complete. We know that muscle in its action burns by preference non-nitrogenous fuel, and that in the intervals of rest its own nitrogenous structure is repaired. The consumption which goes on in it during action is the burning of fuel for an outcome of work; while that which takes place during rest is in connection with the growth and repair of its proper structure. It is reasonable to believe that a similar law governs the nutrition and irritation of every living corpuscle, and that in the

nervous system, as in the muscular, there is consumption of other than the proper nervous substance in the performance of function. But, whatever may be the state of matters in detail, it is beyond all question that consumption of material of some sort takes place in every nervous act, and that the mental operations in like manner are accompanied by changes in the brain in strictly proportional amount. Here then is proof that a similar quantitative relation to that which exists between brain-development and mental development exists also between brain-change and mental action. True, the information cannot be got very directly, nor in every detail ; yet the evidence is of such a character that, so far as I am aware, no biologist whatever doubts the conclusion that with every mental action, whether intellectual, emotional, or volitional, a corresponding amount of oxidation of material takes place in the brain. And that this correspondence is of the strictest character may be judged from the results of Mosso's researches with the plethysmograph, which, when the arm is enclosed in it, indicates diminution of size in the part with the smallest increase of mental activity; the consequence, as the experiments pretty plainly show,

of a larger amount of blood flowing into the brain ; and, in any case, however we may explain it, demonstrating physical alterations throughout the body in consequence of physical change in the brain.

If however, it be asserted, as, unfortunately, it sometimes is, that the thought and the cerebral change coincident with it are one and the same thing, I can only answer that such a suggestion is to me unthinkable, and therefore gives me no light on the subject. Any physical change, whatever its character in detail, is mere movement in space, and that is an idea utterly incomparable with the idea of thought. Each thought, each memory has a distinctness from all others, at the same time that it exists for the thinker alone ; while not only is physical change an objective antecedent of the subjective changes by which it is appreciated, but the particular physical change which takes place in any "nerve-cell" or living corpuscle of the brain when in action is always of one and the self-same description, to wit, a combustion or oxidation and an accompanying electric disturbance. We know of no other changes than these in either nerve or muscle when in action.

For a moment I may pause in my argument to

point out the exceedingly interesting character of the electric changes referred to. Living muscle and nerve separated in blocks from the body, so long as they are at rest are in a state of remarkable electric tension of a description different from anything found in dead matter; but as soon as they are irritated, and so put into the active condition, this tension is diminished or ceases. No one, so far as I know, can tell what these things point to, but surely it is remarkable that power to pass into the contracted or the nervously active state should be indicated by an electric condition not found in dead matter, and that the exercise of the power should remove the distinctive electric condition.

I explained, a little while ago, the nature of reflex action, how, beginning at the surface, it passed through a nervous centre, and returning thence resulted in movements or other actions through the body. Let us now try, so far as we may, to follow the series of changes when consciousness intervenes. The irritants which, applied to the body, may cause sensation are of many different kinds. The general surface may be affected by mechanical, chemical, thermal, and other applications, and the organs of

special sense by luminous and sonorous vibrations, and sapid and odorous particles. But, in every instance, what happens is that nerves pass into the active condition; this active condition travels into the brain, and, happen how it may, sensation of touch, warmth or cold, light, sound, taste, or odour follows. *The degree of sensation varies according to the amount of the stimulus and the irritability of the nerves and brain, provided always that the attention is the same.*

But this element of attention is variable and demands looking into. It may be diminished by sleep, a condition depending on alterations of nutrition little understood; or it may be turned in other directions, in which case the amount of its preoccupation will be proportional to an amount of irritation of brain-substance caused by it. The details of the manner in which an external sensation is modified by that state of matters are uncertain. Two suggestions may be made on the subject. In the first place, and I suppose this will be generally agreed to by biologists, there may be circuits of action in the brain, when the thoughts are turned in on themselves, incompatible with the travelling of action from the surface of the body to the cerebral hemispheres; for the nerves are

structurally continuous with the nerve-cells or special living corpuscles of the spinal cord and base of the brain, and only through these are connected with the hemispheres; and the circumstance that reflex actions take place best both in cord and brain when there is complete unconsciousness of the stimulus seems to show that action is shunted off at these corpuscles in different directions in different circumstances, though the mechanism which regulates the shunting is entirely unknown. The other suggestion is that the explanation of the varying amount of attention given to a sensation from without is to be found principally not in the structure of the brain, but in the limits of the mind; a certain total sum of consciousness being all that is possible at one moment, so that the more it is occupied with one topic, the less is left for any other.

Leaving, however, that puzzling question, I wish now to point out that although the sensation is in ratio to the stimulus, *the amount of subsequent mental action set up by a sensation has no quantitative relation to the sensation, and, therefore, none to the amount of energy liberated by the stimulus.* No doubt from a given amount of stimulus applied to a

given nerve a fixed amount of action will be set up in the nerve, and travelling to the brain will, if the brain be in precisely the same condition, always produce in it precisely the same immediate changes. The mind then, in consequence of the changes in brain and nerves, whatever the mechanism by which it is reached, undergoes the change termed sensation ; the sensation is instantaneously followed in the mind by perceptions, emotions, and, it may be, other actions, following one on another, and varying in degree ; and these changes are themselves accompanied by brain-action corresponding to them, no doubt, exactly in amount. Thus a given amount of physical stimulus to an organ of sense becomes the excitant of very variable amounts of action, both mental and cerebral ; but only in an indirect manner. It is precisely as the spark from a percussion cap may in one instance explode a grain, and in another a ton of powder, but can only explode one minute portion of powder, in any case, directly ; the rest of the explosion takes place by the transmission from grain to grain.

The more this matter is examined, the more interesting it becomes. It seems hardly to have been

looked at fairly in the face. I find myself forced to a conclusion which I have not hitherto held, namely:—that the mind, non-material though it be, is affected by physical change in brain-substance, and that in the initial mental process, to wit, the sensation, the cerebral is the antecedent of the mental change; while, in the whole train of mental phenomena succeeding the sensation, the mental changes are the antecedents of the cerebral changes which accompany them. It is not sufficient to say that the mental and physical actions are simultaneous; for in the case of sensation you come to a stage—a transition-point—at which the purely physical changes are followed by change both physical and mental; and in the origin of voluntary and emotional actions of the body there is a point of converse transition at which mental plus physical change is followed by purely physical change. Therefore, the question remains what is the relation of the mental part of the action during the mixed or intervening process to the purely physical actions before and after.

Has, then, the energy the conservation of which has become one of the greatest laws for the physicist a larger circuit here than the mere material universe?

That is a startling question to present itself; but once presented, I see no escape from answering it in the affirmative. It does not seem to have generally occurred to thinkers to track sufficiently in detail the steps, physical and mental, from the stimulation of a sense-organ to the operations of mind and brain consequent on sensation, so as to see that there is a transition-point where such a question is inevitable. But the inexorable question having been raised, there are only two alternatives :—at this transition-point, either the physical results of the action in the nerve-cells amount to the same sum as they would in the case of the same action in cells unconnected with the mind, or they amount to a smaller sum : if to the same sum, then the change in the mind is a something which, while brought about by physical energy, is yet additional to the constant quantity, and to that extent transgresses the physicist's law in a region external to his domain ; if to a smaller sum, then the difference is transformed from physical to psychical energy, and the bridge looms vaguely between the physicist's and that other territory. But it is difficult to imagine that the former alternative can be true, seeing that at any moment, without change of exter-

nal circumstances, the volition can initiate physical operations leading to movements of the body, and similarly can stop the same, and must, therefore, start the brain-changes which are its own necessary accompaniment. According to the reading of the mechanism of sensation to which this argument forces me, and which I put forward with all the diffidence which so startling a result suggests, *a certain minute amount of energy in the production of sensation quits the physical for the psychical world, instantaneously to return again in the excitation effected by the sentient mind on the substance of the brain.* While, as already said, the statement that thought is a form of physical energy cannot possibly convey any meaning, it is not only possible, but apparently necessary to admit that thought and physical energy are mutually convertible; nor will this statement long continue after all, perhaps, to wear a startling aspect to those who grasp that Spirit is the one substratum of everything.

It must also be observed that as soon as it is appreciated that mental action is either prior or subsequent to the physical change with which it is immediately associated, the important admission must follow that there is an element of mental

existence independent of the body, namely, that on which the nerve-change acts in the case of sensation, and from which that volition comes whose action is linked with the brain. In that sphere, and not in the shape of potential vibrations laid past in nerve-cells, I believe it is that latent memories are stored ; and I know not how much else there may be within it.

I have spoken of the amount of energy which acts on the mind in the production of sensation, as being probably minute. Let me explain the grounds which lead to that belief. In experiments on nerves, an exceedingly slight stimulus, mechanical or electrical, is sufficient to affect a nerve, throwing it into the active state. If a motor nerve, with muscle attached, be chosen for the experiment, the irritation contracts the muscle ; but it does not do so directly. It only puts the part of the nerve where it is applied into the active condition ; and that active condition then communicates itself to the parts next in position, travelling at a rate somewhat variable, but exceeding a hundred feet per second, until this active condition in the terminations of the nerve communicates itself in like manner to the muscular tissue. The action

seems to be like the travelling of the flame in a train of gunpowder. The active condition at any one spot of the nerve causes, there can be no doubt, combustion, oxidation of substance, with a certain liberation of heat, and only a small portion of the energy is expended in throwing the next portion into a similarly active state. Thus, also, there can be no doubt that brain-substance lighted into activity by irritation coming from nerves, produces, as a result of its action, so much heat, carbonic acid, and water; but there seems little chance of our ever determining exactly what the precise physical changes are, nor how their amount may vary according as the mind is acted on or not.

The operations which take place when from the mind fiats go out to perform movements of the body come next to be considered, and need not, after what has been already said, occupy us long. Consequent on the effort of the will, physical changes take place extending from the hemispheres of the brain through nervous tracks to the various groups of muscles which contract harmoniously to produce the exact result wanted. Yet, while complex systems of individual muscles are thrown into minutely regulated action, it

is not the individual actions of muscles but the net result of the action of the whole mechanism which is the thing of which we have knowledge. A rope-dancer has no knowledge whatever of the muscles by which his movements are performed ; while an anatomist, skilled in the uses of muscles, not only might be a very bad rope-dancer, but, most certainly, would not be able to guide his body on terra firma so well as a moderately drunken man (if I may use the expression), were he obliged to depend on his anatomical skill for his progression. No one ever finds occasion with open hand to dimple the inner side of the palm, or dreams, I suppose, of doing such a thing for the sake of doing it. But, when the medical student dissects the muscle by which that action can be performed, he sees, from its position, that it must pull upon the skin there, and looking at his own hand makes a conscious effort, and, in most cases, produces the result at once. In that case you might think that the knowledge of the muscle helped the action ; but it is not so, for anyone watching the bending of his fingers directs his attention to the fingers themselves, while, in point of fact, the muscles moving the fingers are up in the forearm. I shall give only one other

illustration of the voluntary action of muscles; and I take it from a muscle not usually termed voluntary by anatomists, yet which is as much so as any other muscle in the body. The focusing of the eye alternately to near and distant objects is effected with facility. But so far are we from being conscious of the apparatus which carries out our will, that it is a quite modern discovery that it is done by muscular action in the interior of the eyeball; and this is the more interesting as, before Helmholtz settled the matter, physicists had quite a multitude of ingenious explanations other than the right one.

In endeavouring to throw light on the connection of the mind with the body, it is important to know if the cerebral hemispheres have no other function than as organs of consciousness, and if this function is strictly limited to them. In answer to the first question we are entitled to say that the whole function of the hemispheres is in connection with consciousness, but is not on that account disconnected with the function of the rest of the nervous system; for it is both set in action by the other parts and in turn acts on them; so that it is the property of the working mass of the hemispheres, what we call its

grey matter, to be in functional connection both with the mind and with the physical arrangements of the whole nervous system.

But, are the hemispheres the only parts connected with the mind? I for one most strenuously deny it, but honestly tell you that I am generally accounted a heretic; though various physiologists, well able to judge, are aware of the serious difficulties in the way of the prevalent and time-honoured doctrine on this subject. I do not think that sensation can be accounted for without believing that the consciousness works in connection with as much of the nervous system as is at any one time united to the brain by nerve-channels in the active state.*

But letting that pass as too difficult a subject for a non-biological audience, I shall content myself by pointing out that after removal of the hemispheres even birds and mammals continue to perform actions which are indeed sometimes called automatic, but which are undoubtedly full of purpose. The animal sits in lethargic stupor, and does not move except in

* The argument on this subject will be found in the fourth article of my volume entitled "Evolution, Expression, and Sensation," published last year.

response to stimulation. It ceases to initiate voluntary movements from within. But stimulate it from without, and the actions in response are with obvious intent. It is still able to walk, and it turns its head so as, with its eye, to follow the light of a candle. A pigeon, so treated, tossed in the air, stretches its wings, and by flight prevents its fall. In cold-blooded animals, purposeful actions are performed even after the whole brain has been removed. A strong frog carefully decapitated can be made to leap, and with its hind legs will endeavour to push away an instrument rudely applied to the back part of its body. It was shown by Goltz, and has been often mentioned since, that after removal of its hemispheres a frog, laid on a board or on the palm of the hand, will, when its support is gradually turned round, crawl round the edge and gain the upper surface, so as to keep itself from falling ; and when it is recollected that the sensation of a tendency to fall is little localized, and not due to the application of an irritant, it is hard to understand what else can be indicated by the frog's efforts to save itself, but some twilight lethargic remains of consciousness. It may be left to yourselves to judge

whether such things are explained by calling them automatic, or whether that word so used is not rather mere pedantic cant pawned on the world as wisdom.

From facts such as I have mentioned we shall probably be right to conclude the peculiarity of the hemispheres to be that *in them alone our action can be initiated by volition unstimulated by irritation from without.*

The question whether the whole surface of the hemisphere is to be considered as having one function in respect of intelligence, or whether it is to be considered as consisting of numerous organs in connection with different mental faculties, is one which of late years has got into a rather curious position. The theory of Gall has long since died out, except from the imagination of the unscientific; and whatever truth there may be in the observations of that remarkable man and his disciples is to be accounted for not by the phrenological theory but by physiognomy. But in recent years a vaguer theory of localization of mental functions has arisen, in accordance with the habit now prevalent among biologists of building enormous theoretical superstructures on facts un-

doubtedly good in themselves, but inadequate to support the doctrines raised on them. It appears from the experiments of physiologists, particularly those of Fritsch and Hitzig, and the more extended and altogether invaluable experiments of the much and disgracefully persecuted Dr. Ferrier, that irritation of certain limited portions of the surface of the brain produce movements of different parts of the body, while destruction of them produces corresponding paralyses. Also blindness, deafness, and loss of smell result severally from the destruction of three different portions of the hemispheres. But the whole region over which such experimental results are obtained is limited, situated on the side, and neither extending to the foremost nor the hindermost parts of the hemispheres. The observations thus made on the lower animals have been followed by much remarkable discovery of partial paralysis in the human subject due to local lesions of the surface of the brain, a discovery most important to the practitioner, but which would have been impossible had not the experiments on monkeys been made.

Another important set of pathological facts discovered prior to those just mentioned have exercised

a powerful influence in bringing about the present belief in separate localization of mental functions, namely, the frequent occurrence of a great variety of defects of speech, usually alluded to in the gross by the name aphasia, which were traced by Broca to lesion of one particular small portion of the brain (the hinder part of the third frontal convolution), and found by him to be occasioned in thirteen out of every fourteen cases by such lesion on the left side of the brain. All these cases of aphasia exhibit this peculiarity, that they do not depend on any paralysis of the organs of voice or speech, but always on a defect of the mind; yet they are of a remarkably variable description—now consisting of a total inability to speak at all, now of incapability of controlling syllables, and in other cases of an uncontrollable impulse to use one word instead of another, or even to repeat whole sentences from memory utterly unconnected with the ideas which you see the patient really wishes to express. In years gone by I had a number of such cases, all of them proceeding from one cause, which is more common than any other—the obstruction of an artery which passes up by the neighbourhood of the part noted by Broca. But the part

referred to may, as is generally admitted, and I have myself seen, be entirely destroyed, along with much more, by slow disease, without any interference with speech. Probably the phenomena may depend on the circumstance that the proper exercise of speech involves the carrying on of a great number of mental processes at the same time, most of them indeed performed ordinarily with little attention bestowed on them, but yet of very different descriptions, such as the formation of the letters, the selection of the words, some attention to grammar, the idea to be expressed, and the sequence of ideas in consecutive sentences. All these processes must take place together in correct and continuous speech; and all of them were slowly and painfully learned in early life. Even the individual movements, the combination of which is required to produce the sound of certain letters, are performed at the demand of the will, and it is no explanation to say that habit has made these movements automatic. Far better was the explanation of habitual movements offered long ago by Dugald Stewart, that the attention given to them is so slight as to leave no trace in the memory. A damage to any considerable depth at the particular

spot noted by Broca will certainly destroy a more than usual number of nervous connections between different parts, and probably thus destroy that consentaneous action of great tracts of brain-substance which may be necessary for the carrying on of so many mental processes at one time; while, in addition, it is possible that connections with the organs of speech may reach the hemispheres at this very spot, though against that being likely is to be put the fact that there is no paralysis in aphasia.

But a similar suggestion may be made with regard to all the areæ whose damage affects movements of parts of the body, or any of the organs of special sense. The peculiar effects observed in experiment and disease probably indicate merely that there is a more direct anatomical connection uniting each area to the part which can be influenced through it than unites it with other parts. That is to say, it is quite possible that the whole grey matter of the hemispheres is in uniform relation to the mind, although its different parts stand in more or less direct communication with different parts of the body.

If it be asked what objection there is to believe, as

so many physicians do, that one part of the surface of the brain is a definite organ of speech, and that other areæ are organs of movement of different parts of the body, or exclusively appreciate sensations from some one organ of special sense, it is to be answered —first, that instances are recorded of destruction of "motor areæ" unaccompanied with any paralysis; and one clear case of this sort is, as Ferrier justly admits, sufficient to call on the theorist to pause. Secondly, there is abundant evidence, as we have already seen, that the hemispheres considered in their entirety constitute the organ of thought; and if we admit that the effects produced in experiment, and corresponding effects produced in disease by irritation or destruction of these different areæ, arise from those parts being special organs devoted to the functions interfered with, we must suppose the existence of many more such organs devoted to other and various mental functions. But the evidence at present does not bear this out. Tumours, abscesses, and other sources of damage occur all over the surface of the brain, and often go on for a long time without betraying their presence by any obvious effect on the

patient's mental nature. Persons have recovered from musket balls passing right through their skulls, as well as from injuries which have caused portions of brain to protrude so that the surgeon has been obliged to shave them off; and the injuries in these cases have been variously situated. But it has not yet been demonstrated that the patients show any loss of particular mental faculties varying according to the site of injury, though usually they exhibit increased irritability, such as may well be accounted for by the increased irritability of tissue which has been wounded or inflamed.

In these circumstances, and recollecting that the active condition of nervous matter is always of the same description, though the operations of the mind, including its memories, are innumerable, I am content to side with the minority of my profession, and to hold that there is no sufficient reason for believing that different mental functions are carried on in connection with different parts of the cerebral hemispheres. But the question is difficult, and the data as yet are insufficient to guide to a certain answer. It is one in which judicious experiment may help us yet,

and possibly conduce to the improvement of the treatment of maladies of the gravest kind. But it would appear that in this great country we must in future be content, so far as experimental investigation is concerned, to pick up crumbs from the continental table, without offering due return; because our legislators have declared in the name of the nation that it is legitimate for them to spread unknown torture among animals in sport, but not legitimate to advance knowledge at the expense of an immeasurably smaller amount of pain.

The very different manner in which emotions act on the body from that in which the volitions do may seem to favour the theory of localization of different mental conditions in different parts of the hemispheres; but it may be otherwise accounted for. Thus the nature of intellectual effort appears not to be of such a kind as to cause such exaltation of corpuscular activity in the brain as is caused by invigorating emotion; and the superabundance of the action in the latter case may be the cause of its spreading along the channels which influence the vascular system; and conversely, a general explanation may be arrived at

of the diminution of the heart's action from depressing emotion. Faintness, blushing, and, probably, also shedding of tears, are other results of diminution of normal action in certain parts of the nervous system; sobbing and palpitation results of exaggerated and tumultuous action.

I cannot conclude without recording my dissent from the doctrine at present fashionable among physicians, that all alienation of mind is necessarily the result of structural change in the brain. The success of physical methods in science invites us to look for physical causes of all sorts of phenomena; but all medical men will surely grant that, in this instance, we have not yet even usually found them; and, happily, the modern treatment of the insane is directed even more to their thoughts than to their bodies. Let us put the whole matter in the form of a frank confession of ignorance. We do not know why one man has a jumbled intellect, and another has erratic desires or ungoverned emotions. But we certainly have no evidence that different parts of the brain are involved in these different conditions. We ought not to assume that the microscopic elements of

the brain are repositories in which ideas can be locked up, as bottles are laid by in a cellar. But, although I think it very possible that there is no other connection between mind and brain than a quantitative one to the effect that so much total nervous action at any one time going on in the brain corresponds with so much total action going on in the mind, without reference to the nature of it, I cannot shut my eyes to the pertinancy of this answer, that though the active physical condition of brain-corpuscles is no doubt uniform in kind, the nature of the connection of the corpuscles with the mind is unknown. In these circumstances I content myself with arguing the matter thus:—We know that the total amount of mental manifestation at any one moment is limited by the total amount of brain-action possible; and if, habitually, this limited amount of mental activity has been entirely occupied with particular sets of ideas so as to leave no spare energy for others, whether the habitual ideas have been directed to questions of reason not carefully worked out to distinct conclusions, or to emotions or impulses indulged in out of due proportion, I can see no reason why the mind, so

long as it is limited in its gross total operations, should not be distraught in ways otherwise totally independent of the brain.

I fear I have chosen much too difficult a subject: but I shall not have spoken in vain if I have led you to think of the depth of ignorance in which we are involved, and the hastiness of the assumptions which we are liable to make.

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