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Also the presentation of the following works to the Library:—

"Proceedings of the Royal Society"	*From the same.*
"Proceedings of the Royal Asiatic Society"	"
"Proceedings of the Royal Dublin Society"	"
"Proceedings of the Royal Geographical Society"	"
"Proceedings of the Royal Colonial Institute"	"
"Proceedings of the Royal Institution"	"
"Proceedings of the Royal Irish Academy"	"
"Proceedings of the Royal United Service Institution"	"
"Proceedings of the Royal Society of Canada"	"
"Proceedings of the Royal Society of New South Wales"	"
"Proceedings of the Geological Society"	"
"Proceedings of the Society of Arts"	"

Also the Proceedings of many Colonial and Foreign Societies.

The following Paper was then read by the Author:—

FROM REFLEX ACTION TO VOLITION. By Dr. ALEX HILL, Master of Downing College, Cambridge.

AN anatomist as such has no affair with the analysis of mental processes. My professional work consists in attempts to understand the structural relations of the several parts of the central nervous system; to give, what is very far from complete as yet, an account of the mechanism by which thought is produced; not to explain its mode of working. Still it is impossible for any one who is constantly occupied in the study of the Brain to avoid speculating as to the way in which it does its work. Feeling, emotion, thought, all the manifold phenomena of mind-life are but the products of the brain's activity; how far does a study of the apparatus in which they are produced help us to classify these phenomena? How far does a subjective analysis of the phenomena help us to understand the Construction of the

Machine? Wide as is the gap between the tissue which lies upon the stage of the microscope and the functions of which, when alive, that tissue was the seat, the anatomist who is constantly occupied in the study of the nervous system cannot refrain from attempting to answer the question: "How does it do its work?" Fastening facts as steps upon the face of the knowable, we attempt to climb as far as they will carry us in order that we may take a wider survey of the unknowable. No two thinkers assign to their data the same value, or use them in the same way; nor have we any means of deciding who has climbed the highest or sees the farthest. The views which I wish to lay before you to-night are merely the reflections of an anatomist as to the functions of the tissue at which he works, not the analysis by the psychologist or metaphysician of the phenomena of mental action. Nevertheless, this paper must to a certain extent treat of its subject from both sides. Looking up from the microscope the anatomist asks himself: "What is the work which the brain has to do?" Attempting to picture it in action he turns from the fabric to the machine, from the machine to the fabric, in his efforts to realise the relation between the two.

May I use this illustration of the fabric and its manufacture, to explain the objects of this paper? Let us imagine that we find ourselves placed before a curtain-making machine, and its wonderfully intricate product a lace curtain, and that we try by contemplating the curtain on the one hand, and the machine on the other, to realise the machine in action, the curtain in process of formation. Look first at the curtain, a labyrinth of threads, crossing and recrossing, looping and knotting, in apparent confusion, but each thread holding its proper place in the pattern, taking part in the realization of a design, which when seen as a whole, conveys what seems to be a simple idea, a picture it may be of fruit or flowers. The machine in which this intricate texture is woven must, to some extent, resemble its product in complexity and delicacy; and it is not without an object that I choose the lace curtain for my illustration. It suggests the fabric, the formation of which we wish to investigate. The thought which—preceding volition—flashes, as we say, into the mind, presenting to our consciousness what we take to be an integral idea, is like the curtain woven of many threads, the ends of which reach far backwards in our lives. It is made up of the experiences of a lifetime, and each experience of countless filaments of sensation.

How dull a paper this promises to be is the half-formed thought of most minds in this room! But what a complex product of experience is this simple thought: experience of other papers, judgment of character, recollections of efforts made to struggle with metaphysical subjects.

The metaphysical side of the problem is the aspect which I wish to avoid as far as possible. It is the thoughts of an anatomist that I have to offer. I must therefore ask you to follow me in tracing the evolution of the nervous system from the beginning. Which of all the mass of facts accumulated by the patient research for the most part of very recent years shall we select as steps on which to climb? First we must ask what is the ground from which we start—where in the animal kingdom does the nervous system first appear? There are animals which have none; but it is not possible to trace its genesis as clearly as we could wish. Some points, however, are absolutely clear. It is certain, for instance, that in all animals the whole nervous system is formed from the layer which, in the rest of its extent, becomes the skin. It belongs to the surface of the body, the layer, that is to say, which alone is exposed to the impact of impressions from the outer world. It is also clear that before a nervous system is formed, certain regions of the surface are, owing to their favourable situation, marked off as outposts for observation, as sense-organs. From the epithelial cells of these sense-organs, thin processes, or nerves, are prolonged to the muscle fibres contraction of which enables the animal to make the appropriate movement for escaping the danger, or seizing the food, of the presence of which the sense organ conveyed information. It is also clear that the nervous system, properly so called, is first formed by the deposition from the surface of certain of these sensory cells, the union of whose processes into a network or plexus, provides for the transmission of the impulses received by their more fortunate sisters not only to the muscle fibres, with which the cells on the surface may be supposed to have been in primitive connection, but also with a variety of muscles, the contraction of each of which is appropriate to the particular *kind* of impression received. Examine now the way in which this primitive nervous system works. It may be said in the jelly-fish to have reached the stage of evolution just described, and no animal (as Dr. Romanes was the first to recognize) is more accessible to experiment. It is not necessary for the purposes of this paper to follow Dr. Romanes and others through the

elaborate investigations which they have made into the working of the nervous system in this animal. We have probably all of us made such observations as are necessary to determine its fundamental properties. Watch the jelly-fish as it feeds on a rocky coast. The rhythmic pulsations of its pellucid bell bear it gently to and fro within a closely circumscribed area. At one moment the wave washes it close to the rock; at the next it has turned on to its side and a few pulsations carry it safely out of danger. However difficult it may be to compare its sensations with our own, they are undoubtedly of such a nature as to give it warning of danger, or rather to produce the movements by which the danger is escaped. What a contrast there is between the beautiful sentient and motile organism at work in the sea and the helpless lump of jelly cast up on the sand. As long, however, as it has life the function by which its movements are determined can be shown to exist. Stroke the stranded jelly-fish with your finger, and if it still lives each stroke is answered by an attempted contraction of the bell, a movement which follows the stimulus with unvarying regularity, after an easily-determined interval of time. The only evidence which we can obtain of the functions of the nervous system in the jelly-fish, relates to this unerring mechanical response to stimulus; Reflex Action.

To reflex action there are progressively added other functions, of the nature of which we can only form an imperfect picture by a process of subjective analysis, but the existence of which we infer from their effects in the exhibition of what we may term without staying to define or limit the expression "the power of choice."

Compare the frog with the jelly fish. The healthy, uninjured frog displays in its behaviour evidences of a power of selecting its actions. Frighten it and it may jump away, or it may under apparently exactly similar conditions refuse to move. Remove the brain of the frog (an operation which it bears with remarkable impunity), and carefully keep it moist and fed, and for the rest of its life, which may easily be prolonged for a year or eighteen months, we have in our hands a machine which responds infallibly to every stimulus, but never makes a move in the absence of an easily recognised provoking cause.

It is easy to show, however, that there are many actions over which the uninjured frog has no control—which are purely reflex—and my object is to trace the relation to one

another of actions which, in their pronounced forms, we distinguish as reflex and voluntary respectively.

Much light is thrown upon this subject by a study of the tissue, the "grey matter" of the central nervous system, in which these actions are carried out.

It belongs to two great divisions:—(1) The grey matter of the spinal cord and of the central canal of the brain; and (2) the grey matter which covers the surface of the brain. The former is the earlier or more primitive formation, the latter appears much later in the animal series, and only reaches a considerable development in its higher members. The structure of the two is however fundamentally similar. Each consists of a network into which afferent or sensory nerves pour their impulses, and out of which efferent or motor nerves take their start. The filaments of the network are the ramifying processes of cells. Most of the cells are small, but those which support motor nerve-fibres are large; the reason being, apparently, that the long nerve fibre, which runs perhaps to a distant muscle, derives its nourishment from the cell out of which it grows. Time would fail me to give an account of the constitution of this network, nor am I for another reason sorry to pass it by with a hasty notice, for it happens that during the last year or two entirely new views as to its constitution in detail have been advanced, and are still *sub judice*.

The only marked difference between the grey matter of the brain and that of the spinal cord which we can point out is that whereas the spinal cord receives sensory nerves and gives origin to motor ones, the cortex of the brain is, so far as we know, connected with the periphery only through the mediation of the central grey matter, or plexus of the spinal cord.

These are the only points with regard to the evolution and anatomy of the nervous system of which I wish to make use for the purposes of my argument. 1st. It is formed from the surface of the body. 2nd. It is in the first instance intimately connected with the sense organs. 3rd. That it consists of a plexus by means of which the cells of the sense organs are placed in connection with muscle fibres. 4th. That in the lowest animals it is the function of this network to transfer sensory impressions to the appropriate motor mechanism. 5th. That in higher animals the direct and inevitable transfer of impulses gives way to a greater or less extent to the power of choice.

In vertebrate animals, a second field of plexus, the cortex of the brain, is superadded to the primitive grey matter of the spinal cord. Several questions must however be answered before we can correlate this with any distinct advance in the performance of the nervous apparatus. We do not know whether the elements contained in this cortical formation are already present in invertebrate animals; nor do we know what relation the great masses at the base of the cerebrum, the corpora striata (which constitute the bulk of the birds' brain), bear to the mantle or cortex proper, which does not really make its appearance amongst vertebrates until the cartilaginous fishes are reached. Much as we should like to regard the first appearance of the cortex as a great step in advance in the evolution of the central nervous system, we must at present refrain from drawing wide conclusions, and merely note the fact that the nervous system of higher animals is divisible into two parts; that it consists of a vast aggregation of elements which, so far as we can see, are not marked by any differences in character or even in arrangement. The fibres which connect the inner grey matter with the surface of the body, pour their impulses into a network from which motor fibres take origin. The grey matter presents therefore a variety of routes through which sensory impulses may flow over into motor paths, each sensory-motor path constituting an arc.

But on the arcs which collectively make up the lower system are superadded arcs, the loops of which lie in the higher grey matter. At the same time, therefore, that an impulse flows across the spinal cord, as a simple direct reflex action, a certain part of this impulse is also diverted to the brain along fibres which ascend in the outer part of the spinal cord; and from the brain descending fibres carry the impulse back again to the lower arc. Let us try to avoid expressions which convey a more concrete idea of the relations of these two sets of arcs to one another than we are at present justified in formulating; and above all let us avoid terms derived from commerce, military organizations, and other developments of social activity which would be but coarse symbols to apply to this relation, of the exact nature of which we are able to form but a dim picture, and let us say that we see in the superposed arcs of which there may be, for aught we know, not two only, but many, opportunities for the control, the reinforcement, the restraint of reflex action. Accurate measurements of the time taken by impulses in travelling through

the grey matter have done much to throw light upon the route they follow; but we do not yet know whether we ought to speak of the conversion of a sensory into a motor impulse, as its passage through the lower network under the direction of nerve currents which originate in the higher; or whether the impulse when it reaches the lower grey matter takes in some cases a direct cross path, while in others it makes its transit through a longer loop. One thing is quite certain, namely, that the routes which are most frequently used are the most open, and therefore the most easily traversed.

Of all the impulses reflected through the grey matter, the most frequent are those upon which the position of the body depends. As we stand upright the body sways ceaselessly backwards and forwards. Swaying backwards, muscles on the front of the thigh are stretched. The stretching gives rise to an impulse which travels up to the spinal cord and down again to the muscles leading to their contraction. As our weight falls forwards the muscles of the calf are stretched, contract, and restore the body to the erect position. These adaptive movements are made unconsciously many times in every minute. The reflex route is always open. Afferent and efferent nerves are, as it were, constantly "switched on" through the grey matter. The flexor and extensor muscles which play over every joint, bear this see-sawing relation to one another. But peculiar interest attaches to the contraction of the extensor muscles of the thigh, for the reflex action by which this is brought about can be very easily demonstrated in almost all healthy people, and can be used as a very sensitive test of the condition of the spinal cord when this is diseased. A person sits in an ordinary upright chair, with one leg crossed over the other, the muscles lax, and the foot hanging free. If then the tendon below the knee-cap is gently tapped, the slight sudden stretching of the muscles of the thigh so produced, leads to their contraction and the sudden jerking forward of the foot. This "knee-jerk," as it is termed, occurs with such rapidity, that physiologists have had difficulty in understanding how it could really be a reflex action. The jerk follows the tap in ·03 second. If, therefore, we deduct the time taken by the impulse in ascending to the spinal cord and descending to the muscle, we find that the passage of the grey matter occupies no more than ·01 to ·015 second. This is only a type of a large number of similar adaptive movements, but I dwell

upon it particularly because it is a pure reflex allying us to the jelly fish, and sweeping away, if properly understood, several fancied distinctions between the mode of action of the nervous system in ourselves as compared with lower animals. It is a pure reflex. It is carried out in the complete absence of consciousness. The movement has no representation in consciousness. It occurs with equal readiness in waking and sleeping, in persons upon whom it has often been tried before, and in those who have no idea of the result likely to follow upon the tap.

Let us use the knee-jerk as the starting point for an analysis of action. The knee-jerk is an unconscious reflex. From this, as zero, in the scale of consciousness, it is easy to construct a table of actions in which the power of control plays an increasingly important part, although all rest equally upon a reflex basis. The foot when trodden upon is inevitably withdrawn. In a choleric person the impulse travels along longer routes, overflowing perhaps into violent action which is equally irresistible. It is easy to picture to oneself the paths in the network as lines of varying resistance, and to imagine the nerve current as choosing the route which offers least opposition to its flow. In its first origin the nervous system is like an open moor, equally easy and equally difficult of passage in all directions. The nervous system as we inherit it is a labyrinth of paths, the depth and breadth of each of which is a measure of the number of impulses which have in our ancestors', as well as in our own lives, passed that way. Practice means the beating down of paths. The facility which comes with practice depends upon the ease with which impulses pass, and this is true not only of simple and obvious reflex actions, but also of such movements as often appear at first sight voluntary rather than reflex; the deftness with which an engraver reproduces a picture on his box-wood block; the astonishing rapidity with which the musician translates certain black spots upon the paper into movements of the fingers; the naturalness with which a cultivated and kindly man answers the needs of his friend with sympathetic glance and courteous action. There is no epoch in life's history at which path-making ends. And here, although not necessary for my argument, I must assert my belief that the nerve network inherited by the individual is a labyrinth of paths which his ancestors have beaten down. Training and circumstance modify the ancestral pattern, so that the network transmitted to our offspring has the form which choice, self-

control, and self-development, whether upward or downward in the ethical scale, have impressed upon it. This is a large question, which would carry me far beyond the province of this paper. At present evolutionists are divided into two camps. Some hold to the older doctrine that under the influence of the environment the organism acquires and transmits tendencies favourable for its existence, while others form the newer school, headed by Weismann, who believes that acquired characteristics are not transmitted, but that the "chance" differences between a number of individuals born under the same conditions tend, when favourable, to improve the individual's prospects in life, while unfavourable modifications diminish the likelihood of his holding his own in the struggle for existence. This doctrine does not carry my judgment with it; it throws back the variations to chance as an ultimate cause. Chance! an expression which in science can only stand for a cause not yet discovered. Weismann proceeds a step further in his reasoning, and draws a wide distinction between the reproductive cells and the rest of the body in which they happen to reside. The body at large, he says, plays no part in determining the structure of the offspring, and therefore no characters which it may acquire can be transmitted. There is no logical difficulty in looking at the central nervous system from this point of view, but it appears to me that observation of human nature demonstrates beyond a doubt that mental characteristics, peculiarities in the form of the network which have been acquired by individual occupation and effort, are handed on to offspring. Theories of evolution are based as a rule upon the study of external form, but it is undeniably true that if the disposition acquired during life by the least of the strands of this inconceivably complicated network is transmitted to a descendant, Weismann's theory falls to the ground.

Hypotheses with regard to its origin aside, the network undoubtedly exists. It is first formed in connection with sense organs, and probably never presents what can be properly called a motor or "kinetogenetic" part. Its function is the distribution of the sensory impulses which it receives into their appropriate nerve fibres, which have their starting points in the larger motor cells.

Up to the present we have spoken of the transmission of impulses as if it always occurred only after such delay as was necessary for the transit through the nerve network. Another step in evolution must now be recognized. It is impossible

to say at what level in the animal kingdom this advance occurs, although it is easy to point out animals in which MEMORY is clearly present, and others like the jelly fish in which such a function, if it exist, is hardly to be shown. In the great majority of animals, although in varying degree, the passage of the impulse is accompanied by molecular changes, which result in its being stored. It is not merely reflected as in a glass, but fixed as in a photograph. Infinite possibilities are opened up by this capacity of the system for storing impulses; possibilities of the combination and comparison of the impulse received from the outer world and about to be discharged in movement, not only with other impressions concurrently received, but also with all the accumulated experiences of the past. Reverting to our former illustration of the effects produced when one person treads upon another person's toe, we see how the impulse may not only flow over into the muscles which withdraw the foot, or return it in a kick, but may be combined with impressions received through the eye which awaken memories of former accidents of the same kind, and the troubles which resulted from a hasty resentment, so that the movement made is not the reflection of one impulse only, but of several; nor of current impulses only, but of these combined with others long ago received. Now we begin to feel as if we had reached the outskirts of thought. If we could watch the machinery in motion, we should see not the shuttle flying backwards and forwards, weaving, twisting, intertwining threads, but nerve currents starting in different, perhaps distant parts of the central system, hastening, checking, combining, disparting, to form the pattern which we recognize as a thought.

My survey of the subject must be confusingly hasty, but there is one other feature of the network, a consideration of which throws a brilliant light upon its mode of working. Hitherto we have spoken of reflex action only. This is the web upon which is woven the many-coloured fabric of intelligence and emotion. From what peculiarities in its quality and amount do the less easily defined phenomena of mental action acquire their colour? The cortex of the brain is, we know, the seat of these higher processes. But twenty years ago it was thought that although the elements of which the cortex is composed are simple, although there are no local peculiarities in their arrangement, although the cortex is in a word remarkably uniform in constitution, its mode of action must be complicated to a degree which baffled investigation.

Now we know that it, like the spinal cord, is a network which receives afferent or sensory fibres, and gives origin (from large cells which look after their nutrition) to efferent or motor ones. A vast aggregation of sensory-motor arcs. Recent investigations have further shown that the fibres which reach the cortex do not come promiscuously from all parts of the lower network, but that it is divided into areas, each of which is in connection, through its lower centre in the spinal cord and the rest of the central grey matter, with a particular sense organ. We owe this discovery entirely to experiment, but the information obtained by stimulating or excising particular regions of the brain can be checked by appeal to other classes of evidence.

Among animals we can easily pick out certain ones whose sensory endowments differ conspicuously from those possessed by most other members of their group. For example, aquatic mammals are deficient in the sense of smell; whether it be because the mammalian organs of olfaction are only adapted for the recognition of bodies suspended in a gaseous medium and cannot be used for the recognition of substances in solution; or whether it be that the respiratory apparatus is closed when the animal is under water, and so there is no opportunity for the renewal of the fluid which fills the nostril, it is a notable fact that however far the groups to which particular aquatic animals respectively belong are removed from each other, the sense of smell is in abeyance in every case. Whales, dugongs, seals, &c., resemble one another in having but little sense of smell or none at all. And with the dwindling of the sense of smell is associated deficiency of the region of the brain known as the temporo-sphenoidal lobe. Dogs and other cursorial carnivora on the contrary possess this sense highly developed, and show a corresponding development of this region of the brain. The herbivora are remarkable for their acuteness of vision, with which is associated a fulness of the occipital lobe. Cats and other crouching carnivora hunt largely by the sense of hearing. Otters find their way among the snags and roots which overhang the dark pools in which they seek their prey, with the aid of the sensitive bristles of the cheek. This list might be almost indefinitely multiplied, but we find from the result of observations upon the brains of animals, as well as from the results of experiment and the observations of disease, that the cortex of the brain is mapped out into areas of separate occupation. There is no division into regions allocated to

separate mental faculties; but we have reason to think, although we have not yet succeeded in accounting for a small portion of the front of the brain, that the whole of the cortex is occupied in the reception and elaboration of sensations.

This brings us a step nearer to understanding the mode of working of the brain. The network of which it consists belongs to the several senses. The kind of work which it does must depend upon the amount of territory in which each sense is represented.

Hitherto we have described the organism as if it were simply a machine for transforming external force into movement. Our actions, our thoughts, our characters are the products of certain forces transmitted, some at once, and others after lying latent, through a network which happens to have a certain inherited form modified by the circumstances in which our lots are cast. Thus is undoubtedly formed the substratum of mental action, the machine with which the mind works. But there is a danger of dwelling upon this aspect of the problem to the exclusion of other phenomena which are equally demonstrable, but which can only be studied by different methods of research. To be perfectly candid I must admit that it was from this *other* side that I wished especially to treat the subject in this paper, but I found that even a hasty statement of the data with which I wished to work, required all the time which I could demand, and more than I ought to ask, of your patience. I must be content with indicating in a few sentences the lines along which my own thought travels in attempting to reach from these data conclusions with regard to the subjects which must ever carry the greatest human interest.

In the description of the principles of construction of the thought-producing apparatus which I have submitted to you, I have carefully avoided the use of any term which implies a knowledge of the processes which go on within ourselves. I have spoken of reflex action, of memory, but not of consciousness. Consciousness is a by-phenomenon which accompanies the reception and transmission of sensory impressions. It cannot be imagined as preceding sensation, it accompanies it. In the evolution of the animal kingdom, it makes its appearance at some point which we can never determine, for we can only judge of its existence in animals by its effects. It cannot be defined, for we can only express it in terms of itself, or in descriptions of the circumstances under which it

is manifest. All that is or ever can be known about it must be deduced from introspection. It is impossible to suppose (and this is really the consideration which removes it altogether from the sphere of the phenomena which we have been studying) that any of the force received by a sense-organ from the outer world, and which travels up sensory nerves into the nerve network, is used up in its production. It is impossible to imagine a balance sheet of force which shall include on the debit side the forces which act upon our bodies from without *plus* the force generated by metabolism within the body and on the credit side:—to the production of consciousness *so much!* The anatomist must let consciousness alone.

But just as movement presupposes sensation so consciousness predicates choice.

It is necessary to be very modest in asserting of a given action that it is a voluntary one. All actions may be performed in the absence of volition, but when there is consciousness of sensation there is also a power of selecting sensations, and therefore of determining the combination of nerve-currents which shall flow out in action. [Considerable applause followed the conclusion of the paper.]

The President (Sir GEORGE G. STOKES, Bart., M.P., V.P.R.S.).—You have already anticipated me in returning your thanks, by your applause, to Dr. Hill for this very interesting and suggestive paper on a most difficult and mysterious subject. I will now invite remarks especially from those who have given particular attention to this subject or to subjects allied to it. Perhaps Sir Joseph Fayrer will open the discussion.

Sir JOSEPH FAYRER, K.C.S.I., M.D., F.R.S.—I think, sir, that there may be others present who would be better able to speak upon this subject than I am; but as you have called upon me I will make one or two remarks—not in the way of criticism, for there is nothing to criticise.

First, I wish to express my admiration of the paper. Dr. Hill has brought before us an exceedingly difficult, and, as you have said, mysterious question, and has done so with judgment and

discretion. The whole of the vast subject of the nervous system he has dealt with in this short paper. He has taken it from a low form of life beginning with the Medusa, but he might have gone even lower, for though in them you find no threads or filaments to indicate a nervous system, there is other evidence of its existence. Dr. Romanes and Dr. Hill himself have shown that first demonstrable evidence of a nervous system. From that rudimentary condition in the lowest organised creature you progress to the brain that wrote the plays of Shakespeare, or that discovered the laws of gravitation. There is remarkable continuity and evolution. As to the brain, if you put a jelly fish at one end and Sir Isaac Newton at the other, the transition is gradual from the one standard of intelligence to the other.

There is much in the paper that is very interesting, and, as the President has said, very suggestive; and where the author speaks of heredity I am very much struck with the value of his remarks. I cannot conceive how any one could have advanced the theory that these things are not hereditary; that they are so transmitted there can be little doubt. I was in the north of Scotland shooting, and in the course of my walks found a dead grouse lying under the telegraph wires, and drew the keeper's attention to it: in the course of conversation he said: "Where we used to get ten of these dead birds, we now get one." I asked him why that was, and he said: "They have got to know it—the knowledge seems to have been transmitted to them. Formerly they used to fly against the wires and kill themselves, while now they avoid them."

The author has spoken of the origin of sensation, and has referred to the otter, the seal, the whale, and so on, the latter being destitute, I believe, of smell, and what would be the use of it? The creature keeps its head under water, and the sense of smell is not transmitted through the water—but the dog has large organs of smell—his mission seems to be perpetually in an atmosphere of it. If you watch a sky-terrier, or other dog, his whole time is occupied in the pursuit of his sense of smell. All this is very interesting, but Dr. Hill has not spoken of anything that we do not share in common (though we have it in a higher degree) with our lower neighbours.

He has not gone into the psychical aspect of the matter. I think if he were to do so it would be interesting, but I quite

sympathise with him in his treatment of the subject, and congratulate him on having done it in an admirable manner. I have great pleasure in endorsing the vote of thanks offered to Dr. Hill for his very interesting paper.

Mr. D. HOWARD, F.C.S.—I have pleasure in offering my thanks to Dr. Hill for his paper, and I hope it will be studied by those who do not know much of the subject, as well as by those who do, because it gives a clear idea of a very interesting and difficult subject, and I hope Dr. Hill will follow it up further with a paper such as Sir Joseph Fayrer has suggested. It is a great advantage to have some knowledge of anatomy, and it is the anatomy of the brain alone that can throw any light on the problems treated of in this paper.

I cannot imagine anything more unwise than to blame such investigations as tending to materialism: we might as well object that the study of the vibrations of a fiddle detracted from the skill of Joachim.

As to the knee-jerk that has been referred to, I can only say it is best tried by somebody who does not know the meaning of it. I have a vivid recollection of it in my boyish days, and it was irresistibly ludicrous, but the other reflex action of the toe is also likely to follow where it is practised on an unconscious school-boy.

Lt.-Colonel T. A. FREEMAN, M.A., Oxon.—"This doctrine does not carry my judgment with it; it throws back the variations to chance, as an ultimate cause. Chance! an expression which in science can only stand for a cause not yet discovered." When I read this in the paper I was reminded of an exceedingly fine expression in Napier's "Peninsular War." Any who have read that work know how he constantly refers to fortune, and I have heard this objected to on religious grounds; but he ends by describing fortune as being "the unknown combinations of infinite power," and he points out that fortune was against Napoleon; and because fortune was against him his immense power in the Peninsula was shattered. If you take that definition I think you will see at once what a magnificent idea it is. Now to pass to one other thing in the paper, as to reflex action, which was spoken of as the "knee-jerk." It brought to my mind something that happened in India some years ago, when an officer was severely injured by a wild boar. He would certainly have died if he had not had a strong consti-

tution. He survived the injury, but for ever after he had a certain spot in one of his arms the touching of which instantly produced the most violent motion of his arm—it was perfectly uncontrollable and independent of his will at all. Of course that was an exceptional movement, whereas the knee-action is normal; but it was an example of action which was purely without volition.

Dr. ROBERT JONES (of Earlswood Asylum), a Visitor.—Mr. President, ladies and gentlemen: I am in charge of an Asylum where mentally afflicted children and imbeciles are received, and I was much struck with that portion of the paper in which Dr. Hill says that faculties, as such, have no special location on the surface of the brain. It struck me very much that from analogy, faculties should have a very distinct location.

Amongst our patients we have those who would strike you as being very peculiar from one special faculty being developed practically at the expense of all the rest—for instance, one knows Gibbon's "Decline and Fall of the Roman Empire" from cover to cover, and another, the History of Achilles to the Siege of Troy without much correction; but they are absolutely devoid of judgment. Another patient can transpose Bach's Fugues at sight, and is also absolutely devoid of judgment. Another patient can construct models. He went to see the *Great Eastern* steamship and came back and constructed an accurate model from memory. These persons would seem to have a portion of the brain abnormally developed. I speak with little authority from an anatomical point on this subject, for Dr. Hill has doubtless examined many portions of the brain, and perhaps he would give me a reason for his belief that faculties, as such, have no special *locus in quo* in the brain. I beg to thank Dr. Hill for his most able paper, which he has given us in very simple diction.

Dr. A. T. SCHOFIELD.—This being my first opportunity of coming here, and being one of the most recent members of the Institute, my ignorance, combined with my intense interest in the subject, must be my apology for rising. With your permission, sir, I would ask one or two questions connected with the paper that Dr. Hill has read. I may say how exceedingly pleased I was to find in his remarks that he established the fact that the paths most frequently used by impulses, become those that are most open and most easily traversed; and thereby endorsed, with all

the weight of his authority, the enormous power of habits, and the great value of training children in all parts of their character by the definite formation of habits. Dr. Hill does not go so far as to say that these impulses or habits actually form in the brain connecting fibres between cell and cell. I believe that is not demonstrated. I do not know whether he would say it is possible, if not probable. Then, further, with regard to impulses, Dr. Hill spoke of the lengthened or higher arcs:—"The grey matter presents therefore a variety of routes, through which sensory impulses may flow over into motor paths, each sensori-motor path constituting an arc." Is sensation the only origin he recognises for impulses? Is he bound by the statement in his paper, that movement presupposes sensation, or does he admit the idea of the presence of cells specially in the frontal regions, which can absolutely start motion in the body apart from all ascertained and demonstrable sensations received from any part of the body? Does he look upon the mind as simply controlling these lengthened arcs, or does he look on the higher nerve centres themselves as having power to initiate action? I would also ask him whether he considers, with regard to volition, that reflex or automatic action comes first in the history of development? He has begun with the jelly fish, but I would ask him if he regards the action of such individual separate cells as compose some of the amœbæ and others as purely reflex, or being, as far as he can judge, automatic? What one wants to get at is whether action, in its first initiation, is really thoroughly ascertained to be reflex in these elementary creatures, which are far lower in the scale than the jelly fish; and whether what we see under the microscope are reflex or automatic movements.

Lastly, as to fixing a locality for the different actions of the brain. Are we to understand that the brain acts as a whole, or that certain regions of it (not of course in any way resembling the "bumps" of phrenologists) are devoted to certain ideas and classes of thought, and may be actively engaged, other parts being at the time at rest? I am afraid my questions are rather crude, but I have great interest in the matter, and I should be glad to have them answered.

Rev. A. I. McCaul, M.A.—I should like to make one remark as to faculties having no location, for it is a point of some interest, and brings to my mind a passage in Aristotle, which I daresay is familiar to the author of the paper, in which he seems to urge that there are

certain portions of the mind, or soul, as he calls it, suited to various classes of knowledge. The passage I refer to is in the sixth book—(Ethics vi, 2).

> "πρὸς γὰρ τὰ τῷ γένει ἕτερα καὶ τῶν τῆς ψυχῆς μορίων, ἕτερον τῷ γένει τὸ πρὸς ἑκάτερον πεφυκὸς, εἴπερ καθ' ὁμοιότητά τινα καὶ οἰκειότητα ἡ γνῶσις ὑπάρχει αὐτοῖς."

In other words; that in reference to the objects of knowledge which are generically different, there are portions of the mind, also generically different, adapted to them.

The AUTHOR.—I must apologize, Mr. President, for not having begun at the commencement of this discussion to take notes of the questions which were asked me, since I did not expect so great a number.

While in the first place I am very grateful for the expressions of approbation which Sir Joseph Fayrer has bestowed upon the paper, I must nevertheless respectfully decline his invitation to follow up the question, from a philosophical standpoint, in a second paper. In this paper I have endeavoured to be as modest as possible, restricting my observations to those branches of the subject in which I have, as I think, information to offer, in the hope that it might serve the purpose of members of the Institute, who are far more competent than myself to apply these data to speculations of the kind which Sir Joseph Fayrer suggests.

Major Freeman's reminiscences are very interesting as affording a striking illustration of the fact that while the greater number of actions are controlled by the will, actions may in certain cases be purely reflex. The power of control is an ever-increasing power, not only in the individual, but also in the race. Our actions however are, as I think, at bottom reflex, although the power of control is so greatly developed that we do not recognize their reflex basis. Many of the things which we do in the day appear to us to be pre-eminently voluntary actions, because we do not recognize that we did the same things under the same circumstances yesterday and the day before. We do not recognize that some sound heard or sight seen is the suggestion which leads to the liberation of nervous impulses which result in appropriate speech or act. No one who has observed the habits of old persons

whose minds are failing, owing to atrophy of the brain, can fail to have noticed the regularity with which given conditions produce given results. Actions which in a robust person would be judged as strictly voluntary, can be induced over and over again by placing the person in the same circumstances which have been observed to evoke them.

Dr. Jones, from his large experience at Earlswood Asylum, criticised my account of location in the cortex of the brain. I think he misunderstood me in the bearing that my remarks may have on phrenology; what I meant was that the faculties, as phrenologists classify them, are not to be localised as tabulated by them. As to the location of faculties in a much larger sense, about that I have nothing to say. I had merely pointed out that the study of the cortex of the brain drives us further and further back, and the more we know the more simple do we find its arrangement to be.

Flourens thought, twenty years ago, that the brain acted as a whole; but we know now that if you stimulate or exert one part of the brain you get a movement of the arm, another part governs the leg, and another part movement of the eye-balls; the whole has been mapped out into areas which are connected with the muscles and certain sense organs controlling their actions.

The instances that Dr. Jones gave of certain persons lacking common judgment and excelling in other things, recalling the form of the *Great Eastern*, for instance, and so on, do not need any special explanation, for it would be an absurdity to regard judgment as a "faculty" capable of localization in the brain. It is most probable on the other hand that the power of recalling the image of things which have been seen depends upon the relative development of certain portions of the brain.

I have been asked a certain number of questions, to answer which would require a much greater knowledge of Plato and Aristotle than I possess. I must therefore restrict myself to the anatomical and physiological sides of the question before us—I was asked, I think, whether the cells in the brain were capable of discharging "ideal impulses," I believe that was the expression. Now the curious thing about the study of the anatomy of the cortex is that the more we go into it, the more we are inclined to give up the notion that the cells have anything to do with the mental processes, except in so far as they serve for the connection

of filaments of the network and transmission of impulses. The function of the cells seems to be to look after the nutrition of the filaments. We cannot find any cell that has any such use as that suggested, viz.:—that it is a kind of little office in which an ideal impression is originated and from which it is discharged.

As to the distinction between reflex and automatic action, again I should say that research into the lower organisms indicates that reflex action is the phenomenon which we can study, and that automatism is a thing which physiology cannot understand. [Applause.]

The PRESIDENT.—I congratulate the Institute on having had a most interesting evening—interesting both as regards the paper as well as the discussion to which it has given rise, and I am sure you will agree with me that our thanks are due both for the paper and to those who have taken part in considering it. [Applause.]

The Meeting was then adjourned.