

[19] The first half of the seventeenth century is one of the great epochs of biological science. For though suggestions and indications of the conceptions which took definite shape, at that time, are to be met with in works of earlier date, they are little more than the shadows which come truth casts forward; men's knowledge was neither extensive enough, nor exact enough, to show them the solid body of fact which these shadows.

But, in the seventeenth century, the idea that the physical processes of life are capable of being explained in the same way as other physical phenomena, and, therefore, that the living body is a mechanism, was proved to be true for certain classes of vital actions; and, having thus taken [20] form in irrefragable fact, this conception has not only successfully repelled every assault which has been made upon it, but has steadily grown in force and extent of application, until it is now the expressed or implied fundamental proposition of the whole doctrine of scientific Physiology.

If we ask to whom mankind are indebted for this great service, the general voice will name William Harvey. For, by his discovery of the circulation of the blood in the higher animals, by his explanation of the nature of the mechanism by which this circulation is effected, and by his no less remarkable, though less known, investigations of the process of development, Harvey solidly laid the foundations of all those physical explanations of the functions of sustentation and reproduction which modern physiologists have achieved.

But the living body is not only sustained and reproduced: it adjusts itself to external and internal changes; it moves and feels. The attempt to reduce the endless complexities of animal motion and feeling to law and order is, at least, as important a part of the task of the physiologist as the elucidation of what are sometimes called the vegetative processes. Harvey did not make this attempt himself; but the influence of his work upon the men who did make it is potent and unquestionable. This man was René Descartes, who, though by many years [21] Harvey's junior, died before him; and his short span of life marks an undoubted epoch in the history of philosophy, but amongst the greatest and most original of mathematicians; and my belief is no less certain, though not less certainly established, that he was deservedly annihilated by, inasmuch as he did for the physiology of motion and sensation that which Harvey had done for the circulation of the blood, and opened up that road to the mechanical theory of these processes, which has been followed by all his successors.

Descartes was no mere speculator, as some would have us believe; but a man who knew of his own knowledge what was to be known of the facts and anatomy and physiology in his day. He was an unwearied dissection and observer; and it is said, that, on a visit to one asking to see his library, Descartes led him into a room set aside for dissections, and full of specimens under examination. "There," said he, "is my library."

I anticipate a smile of incredulity when I thus champion Descartes' claim to be considered a physiologist of the first rank. I expect to be told that I have read into his works what I find there, and to be asked, Why is it that we are left to discover Descartes' deserts at this time of day, more than two centuries after his death? How is it that Descartes is utterly ignored in some of [202] the latest and best works of the subject in which he is said to have been so great?

It is much easier to ask such questions than to answer them, especially if one desires to be on good terms with one's contemporaries; but, if I must give an answer, it is this: The growth of physical science is now so prodigiously rapid, that those who are actively engaged in keeping up with the stream of the organ must necessarily be ignorant of the methods of philosophy, but amongst the greatest and most original of mathematicians; and my belief is no less certain, though not less certainly established, that he was deservedly annihilated by, inasmuch as he did for the physiology of motion and sensation that which Harvey had done for the circulation of the blood, and opened up that road to the mechanical theory of these processes, which has been followed by all his successors.

It is a matter of fact that the greatest physiologist of the eighteenth century, Haller, in tracing of the functions of nerve, does little more than reproduce and enlarge upon the ideas of Descartes. It is a matter of fact that David Hartley, in his remarkable work the "Essay on Man," expressly, though still insufficiently, acknowledges the resemblance of his fundamental conceptions of those of Descartes; and I shall now endeavour to show that a series of propositions, which constitute the foundation and essence of the modern physiology of the nervous system, are fully expressed and illustrated in the works of Descartes.

1. *The brain is the organ of sensation, thought, and emotion; that is to say, some change in the condition of the matter of this organ is the invariable antecedent of the state of consciousness to which each of these terms is applied.*

[204] In the "Principes de la Philosophie" (1649), Descartes says:—
 "Although the soul is united to the whole body, its principal functions are, nevertheless, performed in the brain; it is here that it not only understands and imagines, but also feels; and it is effected by the interconnection of the nerves, which extend in the form of delicate threads from the brain to all parts of the body, to which they are attached in such a manner, as if they were the fine and delicate threads of a net, and the suns are perceived, as if they were in the heavens, by the interconnection of their light and of the optic nerves. So that it is no more necessary for the soul to exert its functions immovably in the soul, than it is necessary that it should be in the heavens to see the stars there."

Elsewhere, he is arguing that the seat of the passions is not (as many suppose) the heart, but the brain, since the following remarkable language:—

"The opinion of those who think that the soul receives its passions in the heart, is of no weight, for it is based upon the fact that the passions cause a change to be left in that organ; and it is easy to see that this change is felt, as if it were in the [205] heart, only by the intermediation of a little nerve which descends from the brain to it; just as pain is felt, as if it were in the foot, by the intermediation of the nerves of that foot; and the stars are perceived, as if they were in the heavens, by the interconnection of their light and of the optic nerves. So that it is no more necessary for the soul to exert its functions immovably in the soul, than it is necessary that it should be in the heavens to see the stars there."

This definite allusion of all the phenomena of consciousness to the brain as their organ, was a step the value of which it is difficult for us to appraise, so completely has Descartes' view incorporated itself with every-day thought and common language. A maxim it is said to be "crack-brained" or "touched in the head," a confused thinker is "middle-headed," while a clever man is said to have "plenty of brains"; but it must be remembered that at the end of the last century a considerable, though much more over-estimated, anatomist, Bichat, so far from having reached the level of Descartes, could gravely argue that the apparatus of organic life are the sole seat of the passions, which in no way affect the brain, except so far as it is agitated by which the influence of the passions is transmitted to the muscles.²

Modern physiology, aided by pathology, easily demonstrates that the brain is the seat of all forms of consciousness, and fully bears out Descartes' explanation of the effects of those sensations in [206] the viscera which accompany intense emotion, to those organs. It proves, directly, that those states of consciousness by which we call sensations are the immediate consequence of a change in the brain excited by the sensory nerves; and, on the well-known effects of injuries, of stimulants, and of narcotics, it bases the conclusion that thought and emotion are, in like manner, the consequences of physical alterations.

II. *The movements of animals are due to the change of form of muscles, which shorten and become thicker; and this change of form in a muscle arises from a motion of the substance contained within the nerves which join to the muscle.*

In the "Passions de l'Âme," Art. viii., Descartes writes:—
 "Moreover, we know that all the movements of the limbs depend on the muscles, and that these muscles are opposed to one another in such a manner, that when one of them draws along the part of the body which it is attached to, and gives rise to a simultaneous elevation of the muscle which is opposed to it. Then, if it happens, however, that the latter shortens, it causes the former to stretch, and draws towards itself the part which it is attached to. Lastly, we know that all these movements of the muscles, as all these draws along the nerves, which are like little threads or tubes, which all come from the brain, and it contains a certain very subtle air or wind, termed the animal spirits."

The contracts of muscle mentioned by Descartes [207] now goes by the general name of contraction; but his definition of it remains untouched. The long-contested controversy whether contractile substance, speaking generally, has an inherent power of contraction, or whether it only acquires it in virtue of an influence exerted by nerve, is now settled in Haller's favour, but Descartes' statement of the dependence of muscular contraction on nerve holds good for the higher forms of muscle, under normal circumstances; so that, although the structure of the various modifying influences, and the mechanism of the contraction, are very different, it is not necessary to extend to an extent of which Descartes could not have dreamed, and have quite upset his hypothesis that the cause of the shortening and thickening of the muscle is the flow of animal spirits into it from the nerves—the important and fundamental part of his statement remains perfectly true.

The like may be affirmed of what he says about nerves, and that "animal spirits" are myriads, but the exquisitely refined methods of investigation of Dubois-Reymond and of Helmholtz have no less clearly proved that the antecedent of ordinary muscular contraction is a motion of the molecules of the nerve going to the muscle; and that this motion is propagated with a measurable, and by [208] no means great, velocity, through the substance of the nerve towards the muscle.

With the progress of research, the term "animal spirits" gave way to a "nervous fluid," and "nervous fluid" has now given way to "molecular motion of nerve substance." Our conceptions of what takes place in nerve have altered in the same way as our conceptions of what takes place in ordinary muscular contraction, since electricity was shown to be not a fluid, but a mode of molecular motion. The change is of vast importance; but it does not affect Descartes' fundamental idea, that a change in the substance of a motor nerve propagated towards a muscle is its own mode of causing muscular contraction.

III. *The sensations of animals are due to a motion of the substance of the nerves which connect the sensory organs with the brain.*

"In La Dioptrique" (Discours Quatrième), Descartes explains, more fully than in the passage cited above, his hypothesis of the mode of action of sensory nerves:—

"It is the little threads of which the interior substance of nerves is composed which absorb sensation. You must conceive that these little threads, being inclosed in tubes, which are always distended and kept open by the animal spirits which they contain, neither press upon nor interfere with one another and are extended from the brain to extremities of all the [209] members to which such a manner, that the slightest touch which excites the part of one of the members to which a thread is attached, gives rise to a motion of the part of the brain whence it arises, just as if pulling one of the ends of a thread connected by the other to a simultaneously moved. . . . And we must take care not to imagine that, in order to feel, the soul needs to behold certain images sent by the objects of sense to the brain, as philosophers commonly suppose; or, at least, we must conceive these images to be something quite different from what they suppose them to be. For, as all they suppose is that these images ought to resemble the object which they represent, it is impossible for them to know how they can be formed by the objects received by the organs of the external senses and transmitted to the brain. And they have had no reason for supposing the existence of these images except this, seeing that the mind is actually excited by the object to which it is directed, they are consequently in error in being excited in the same way to conceive those objects which affect our senses by little particles of them formed in the head; instead of which we ought to recollect that there are many things besides images which may excite the mind, as, for example, signs and words, which have not the least resemblance to the objects which they signify."

Modern physiology amends Descartes' conception of the mode of action of sensory nerves in detail, by showing that their structure is the same as that of motor nerves; and that the changes which take place in them, when the sensory organs to which they are connected are excited, are of [210] just the same nature as those which occur in motor nerves, when the muscles to which they are distributed are made to contract; there is a molecular change which, in the case of the sensory nerve, is propagated towards the brain. But the great fact insisted upon by Descartes, that no likeness of external things is, or can be, transmitted to the mind by the sensory organs; on the contrary, that, between the external cause of a sensation and the sensation, there is interposed a mode of motion of nervous matter, of which the state of consciousness is no likeness, but a mere symbol, is of the profoundest importance. It is the physiological foundation of the doctrine of the relativity of knowledge, and a more or less complete idealism is a necessary consequence of it.

For two alternatives one must be true. Either consciousness is the function of a something distinct from the brain, which we call the soul, and a sensation is the mode in which this soul is affected by the motion of a part of the brain; or there is no soul, and a sensation is something generated by the mode of motion of a part of the brain. In the former case, the phenomena of the senses are purely spiritual affections; in the latter, they are something manufactured by the mechanism of the body, and as unlike the causes which set that mechanism in motion, as the sound of a repeater is unlike the pushing of the spring which gives rise to it.

[211] The nervous system stands between consciousness and the assumed external world, as an interpreter who can talk with his fingers stashed between a hidden speaker and a man who is stone deaf—and Realism is equivalent to a belief on the part of the deaf man, that the speaker must also be talking with his fingers. "Les extrêmes se touchent;" the shibboleth of materialists that "thought is a secretion of the brain;" is the Fichian doctrine that "the phenomenal universe is the creation of the Real," expressed in other language.

IV. *The motion of the matter of a sensory nerve may be transmitted through to motor nerves, and thereby give rise to contraction of the muscles to which these motor nerves are distributed; and this reflection of motion from a sensory into a motor nerve may take place without volition, or even contrary to it.*

In stating these important truths, Descartes defined that which we now term "reflex action." Indeed he almost uses the term itself, as he talks of the "animal spirits" as "réflexifs,"⁴ from the sensory into the motor nerves. And that this use of the word "reflected" was no mere accident, but that the importance and appropriateness [212] of the idea it suggests was fully understood by Descartes' contemporaries, is apparent from a passage in Willis's well-known work, "De Anima Brutorum," published in 1672, in which, in giving an account of Descartes' views, he speaks of the animal spirits being diverted into motor channels, "velut undulationibus reflectis."⁵

Nothing can be clearer in statement, or in illustration, than the view of reflex action which Descartes gives in the "Passions de l'Âme," Art. xiii.

After repeating the manner in which sensory impressions transmitted by the sensory nerves to the brain give rise to sensation, he proceeds:—

"In addition to the different feelings excited in the soul by these different motions of the brain, the animal spirits, without the intervention of the soul, may take their course towards certain muscles, rather than towards others, and thus move the limbs, as I shall prove by an example. If someone moves his hand rapidly towards our eyes, as if he were going to strike us, although we know that he is a friend, that he does us only in just, and that he will be very careful to do us no harm, nevertheless it will be hard to keep from being angry. And this shows, that it is not the eye that is angry, but the soul; since its action is contrary to that volition which is [213] only, or at least the chief, feeling of the soul, but it is because the mechanism of our body is so disposed, that the motion of the hand towards our eyes excites another motion in our brain, and this sends the animal spirits into those muscles which are the organs of the soul."

Since Descartes' time, experiment has eminently enlarged our knowledge of the details of reflex action. The discovery of Bell has enabled us to follow the tracks of the sensory and motor impulses, along distinct bundles of nerve fibres; and the spinal cord, apart from the brain, has been proved to be a great centre of reflex action; but the fundamental conception remains as Descartes left it, and it is one of the pillars of nerve physiology at the present day.

V. *The motion of any given portion of the matter of the brain excited by the motion of a sensory nerve, leaves behind a readiness to be moved in the same way, in that part. Anything which reassociates the motion gives rise to the appropriate feeling. This is the physical mechanism of memory.*

Descartes imagined that the pineal body (a curious apparatus to the upper side of the brain, the function of which, if it have any, is wholly unknown)⁶ was the instrument through which the soul received impressions from, and communicated them to, the brain. And he thus endeavours to [214] explain what happens when one tries to recollect something:—

"Thus when the soul wishes to remember anything, this volition, causing the [pineal] gland to incline itself in different directions, drives the [animal] spirits towards different regions of the brain, until they reach that part in which are the traces, which the object which it desires to remember has left. These traces are produced: these pores of the brain which the [animal] spirits have previously been driven, by reason of the presence of the object, they have thereby acquired a readiness to be opened by the animal spirits which return towards them more readily than other traces, so that the animal spirits, impinging on these pores, enter them more readily than others. By this means they excite a particular motion in the pineal gland, which represents the object to the soul, and causes it to know that it is which it desired to recollect."⁷

That memory is dependent upon some condition of the brain is a fact established by many considerations—among the most important of which are the remarkable phenomena of aphasia. And that the condition of the brain on which memory depends, is largely determined by the repeated occurrence of that condition of its molecules, which gives rise to the idea of the thing remembered, is no less certain. Every boy who learns his lesson by repeating it exemplifies the fact. Descartes, as we have seen, supposes that the pores of a given part of the brain are stretched by the motion of the matter of the brain, and that the part of the brain is stretched. [215] Being imperfectly elastic, does not return to exactly its previous condition, but remains more distensible than it was before. Hartley supposes that the vibrations, excited by a sensory organ, impress, do not die away, but are represented by similar vibrations or "vibraticulations," the permanence and intensity of which are in relation with the frequency of repetition of the primary vibrations. Haller has substantially the same idea, but contents himself with the general term "mutations," to express the cerebral change which is the cause of a state of consciousness. These "mutations" persist for a long time after the cause which gives rise to them has ceased to operate, and are arranged in the brain according to the order of co-existence and succession of their causes. And he gives these permanent "mutations" the picturesque name of *vestigia rerum*, "que non in mente sed in ipso corpore in medulla quondam cerebri ineffabili modo incredibilibus minutis notis et copia innata, inscriptæ sunt."⁸ It does not exist that any modern theory of memory is more fully founded on the facts of the brain, and that the part of the brain on which it is founded, is more fully understood, than that of Descartes. Physiology is at present, incompetent to say anything positively about the matter, or to go farther than the expression of the high probability, that every molecular change which gives rise to a state of [216] consciousness, leaves a more or less permanent structural modification, through which the same molecular change may be regenerated by other agencies than the cause which first produced it.

Thus far, the prepositions respecting the physiology of the nervous system which are stated by Descartes have simply been more clearly defined, more fully illustrated, and, for the most part, demonstrated, by modern physiological research. But there remains a doctrine to which Descartes attached great weight, and to which full acceptance of it became a sort of note of a thoroughgoing Cartesian, but which, nevertheless, is so opposed to ordinary prepossessions that it attracted more general notoriety, and gave rise to more discussion, than almost any other Cartesian hypothesis. It is the doctrine that brute animals are mere machines or automata, devoid not only of reason, but of any kind of consciousness, which is stated briefly in the "Discours de la Méthode," and more fully in the "Réponses aux Quatrièmes Objections," and in the correspondence with Henry More.⁹

The process of reasoning by which Descartes arrived at this startling conclusion is well shown in the following passage of the "Réponses":—

"But as regards the souls of brutes, although this is not the place for considering them, and though without a general [217] exposition of physics, I can say so upon this subject that I have already said in the fifth part of my *Traité on Méthode*; yet, I will further state, that it appears to me to be a very remarkable circumstance that no movement can take place either in the bodies of brutes, or even in the souls of these bodies had not in themselves all the organs and instruments by means of which the very same movement would be accomplished in a machine. So that, even in an animal, or the soul, does not directly move the limbs, but only determines the course of that very visible fluid which is called the animal spirits, which running continually from the heart by the brain into the muscles, is the cause of all the movements of our limbs, and often may cause many different motions, on one easily to be felt."

"And it does not even avoid this determination; for among the movements which take place in us, there are many which do not depend on the mind at all, such as the beating of the heart, the digestion of food, the nutrition, the respiration of those who sleep, and even those who are awake, walking, singing, and other similar actions, when they are not excited by the intellect, but by the mechanism, which may be termed the machine, of the body. And it is not necessary for the soul to be concerned in these movements, but only to be informed of them by the organs of the senses; and thus we see that the soul is not the cause of these movements, but only determines the animal spirits to pass these into the nerves, in such a manner as is required to produce this motion, in the same way as in a machine, and without the mind being able to hinder it. Now since we observe this in ourselves, why should we be so much astonished if the light reflected from the body of a wolf into the eye of a sheep has the same force to excite in it the motion of flight?"

"After having observed this, it is only to be wondered by reasoning, whether certain motions of brutes are comparable to those which are effected in us by the operation of the mind, or, on the contrary, that those which depend only on the animal spirits and the disposition of the organs, it is necessary to consider the difference between the two, which I have before mentioned; but it must indeed be admitted, that not only can we think fit to maintain that the spirit does not move the body, but that it is not necessary for the soul to be concerned in these movements, but only to be informed of them by the organs of the senses; and thus we see that the soul is not the cause of these movements, but only determines the animal spirits to pass these into the nerves, in such a manner as is required to produce this motion, in the same way as in a machine, and without the mind being able to hinder it. Now since we observe this in ourselves, why should we be so much astonished if the light reflected from the body of a wolf into the eye of a sheep has the same force to excite in it the motion of flight?"

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