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PART 1.—ORIGINAL ARTICLES.

*Cerebral Vibrations and Thought.**

I.—"I believe," says Professor Tyndall, "that all the great thinkers who have studied the subject are ready to admit the following hypothesis, that every conscious act, whether in the domain of the senses, of thought, or of emotion, corresponds to a certain definite molecular state of the brain; that this relation of the physical to consciousness invariably exists, so that, given the state of the brain, we may deduce from it the corresponding thought or feeling; or given the thought or feeling, we may deduce from it the state of the brain. But how to make this deduction? At bottom it is not a case of logical deduction; it is, in fact, a case of empirical association. It may be replied that very many of the deductions of science have this empirical character; such is that by which it is affirmed that an electric current circulating in a given direction will make the magnetic needle deviate in a definite direction. But the two cases differ in this, that if the influence of the current upon the needle cannot be shown, it can at least be imagined, and that we have no doubt whatever that ultimately the problem will be mechanically resolved, while we cannot even picture to ourselves the passage from the physical state of the brain to the corresponding facts of feeling. Let it be admitted that a definite thought corresponds simultaneously to a definite molecular action in the brain. Well, we do not possess the intellectual organ, we have not even the rudiment apparently of the organ, which would enable us to pass by reasoning from one phenomenon to the other. They are produced together, but we know not why. If our intelligence and our senses were perfect enough, vigorous enough, enlightened enough to enable us to see and

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to feel the actual molecules of the brain; if we could trace all the movements, the groupings, the electric discharges, if they exist, of these molecules; if we knew perfectly the molecular states which correspond to this or that state of thought or of feeling, we should be still as far as ever from the solution of the problem: what is the connection between this physical state and the facts of consciousness? The abyss which exists between these two classes of phenomena will be always intellectually impassable. Let us admit that the feeling of *love*, for instance, corresponds to a spiral movement of the molecules of the brain to the right, and the feeling of *hate* to a spiral movement to the left, we should know that when we love, a movement is produced in one direction, and that when we hate, a movement is produced in another direction; but the *why* would remain still unanswered."*

Thus the most ordinary experience shows us the two facts inseparably connected, and their representations show them absolutely irreducible into one another. On the one hand, we find that thought depends upon cerebral molecular movement; on the other hand, we cannot conceive that it depends upon it. Thereupon physiologists ignore the latter truth, and say—"Mental phenomena are a function of the nervous centres, just as muscular contraction is a function of the muscles, just as secretion of bile is a function of the liver." On their side, philosophers ignore the former truth, and say, "Moral phenomena have nothing in common with the nervous centres, and belong to beings of a different nature." Whereupon cautious observers intervene, and conclude—"It is true that mental phenomena and molecular movements of the nervous centres are inseparably connected; it is true that to our mind and in our conception they are absolutely irreducible into one another. We are stopped before this difficulty, and do not even attempt to surmount it; we resign ourselves to ignorance." As for us, if we endeavour to make a step forward in this obscurity, it is because it seems to us that we have already made several steps.† On the one hand, we have seen that our most abstract ideas, being signs, are reducible to images; that the images themselves are revived sensations; that, therefore, our entire thought may be reduced to sensations. The difficulty is,

* These are probably not the exact words of Prof. Tyndall, the paragraph being a re-translation from the French of M. Taine.—A. C. M.

† "De l'Intelligence," tome I.

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then, simplified, and the only concern now is to comprehend the connection between a molecular movement and a sensation. On the other hand, we have seen that sensations, apparently simple, are compounds; that these compounds, apparently irreducible into one another, may be composed of similar elements; that at a certain degree of simplicity their elements are no longer perceived by consciousness; that thus sensation is a compound of rudimentary actions capable of indefinite degradations, incapable of coming under the grasp of consciousness, and of which the reflex actions attest not only the presence but the power. The difficulty is found to be simplified a second time, the only concern being to comprehend the connection between these phenomena and molecular movements. The obscurity remains always very great, for we can conceive these phenomena only after the type of ordinary sensations, and between this conception and that of a movement there lies an abyss. But we know that ordinary sensation is a compound; that it differs from its elements; that these elements elude consciousness; that they are not on that account less real and active; and that in this lower and deep penumbra in which sensation is born we shall, perhaps, find the connection between the physical and the moral world.

II.—Let us at the outset state the difficulty in all its force. Since mental phenomena are only more or less deformed or transformed sensations, let us compare a sensation with a molecular movement of the nervous centres. Let us take the sensation of the yellow of gold, of a sound like *ut*, that which the emanations of the lily produce, the taste of sugar, the pain of a cut, the sensation of tickling, of heat, of cold. The necessary and sufficient condition of such a sensation is an intestine movement in the grey substance of the annular protuberance, of the tubercula quadrigemina, perhaps of the thalamus opticus—in short, in the cells of a sensory centre; that this movement is unknown is of little consequence; whatever it be, it is always a displacement of molecules, more or less complicated and propagated; nothing more. Now, what relation can we imagine between this displacement and a sensation? Cells, formed of a membrane and of one or several nuclei, are scattered through a granular substance, a sort of soft pulp or greyish jelly composed of nuclei and innumerable fibrils. These cells branch into fine prolongations, which probably unite with the nervous fibres, and we suppose that by this means they communicate amongst

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themselves and with the white conductors. Place before your eyes and memory the anatomical preparations and micrographical plates which show this apparatus; suppose the power of a microscope indefinitely augmented and the magnifying effect to be increased to a million or a milliard diameters; suppose physiology to be mature, and the theory of cellular movements to be as advanced as the physics of ethereal undulations; suppose that we know the mechanism of the movement which is produced in the grey substance during a sensation, its course from cell to cell, its differences according as it excites a sensation of sound or a sensation of smell, the relation which it has to calorific or electrical movements, still more, the mechanical formula which represents the mass, the rapidity, and the position of all the elements of the fibres and of the cells at any moment of their movement. We shall still only have motion, and the motion, whatever it be, whether rotatory, undulatory, or of other kind, in no way resembles the sensation of bitter, of yellow, of cold, or of pain. We cannot convert either of these two conceptions into the other, and, therefore, the two phenomena seem to be of absolutely different quality; so that analysis, instead of filling up the gap which separates them, seems to enlarge it infinitely.

III.—Repulsed on this side, we must turn to another. In truth, we are unable to conceive the two phenomena as reducible the one into the other; but that may be owing to the manner in which we conceive them, and not to the qualities they possess. Their incompatibility is, perhaps, apparent, not real; it may arise from us, not from them. Such an illusion would be nothing unusual. As a general rule, it suffices for one and the same fact to be known to us by two different ways to make us conceive it as two different facts.

Such is the case with the objects which we know by the senses. One born blind, after being operated upon, is some time before he is able to bring his perceptions of touch into accord with his perceptions of sight. Before the operation he represented to himself a china cup as cold, polished, capable of imparting to his hand a certain sensation of resistance, of weight, and of form; when for the first time it strikes his sight and gives him the sensation of a white cup, he conceives the white and lustrous object as a different one from the thing resistant, heavy, cold, and polished. He would remain at that point if he made no new experiences;

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the two things would always seem to him to have different qualities; they would form two worlds, between which there would be no passage. In like manner, the eyes being shut and no warning given, you behold a bright light, at the same time you hear a sound, and at last you feel in the arm the sensation of a blow from a stick. Try this experiment upon an ignorant person or upon a child: he will believe that he has been struck, that some one whistled, that a bright light entered into the room; nevertheless the three different facts are but one—the passage of an electric current. One must be skilled in acoustics to show that the action that excites in us, by our tactile nerves, the sensation of vibration and of tickling is the same which, by our acoustic nerves, excites in us the sensation of sound. Moreover, recently,* "the phenomena of heat, of electricity, of light, sufficiently ill-defined in themselves, were produced by as many suitable fluid agents endowed with special action. A more profound examination has enabled us to recognise that this conception of different specific heterogeneous agents has at bottom only one sole cause; it is that the perception of these several orders of phenomena is generally effected through different organs, and that, in acting more particularly upon each of our senses, it necessarily excites special sensations. The apparent heterogeneity would be less, then, in the actual nature of the physical agent than in the functions of the physiological instrument which forms the sensations; so that in transferring, by an erroneous ascription, the differences of the effect to the cause, we should in reality have classed the mediate phenomena by which we are conscious of the modifications of matter, rather than the actual essence of these modifications. . . . All the physical phenomena, whatever their nature, seem to be at bottom the manifestations of one and the same primordial agent." Thus the conception we form bears always the deep impression of the procedure which forms it. We are, then, obliged to take account of this impression; wherefore, as soon as we find in ourselves two ideas received by different ways, we should guard ourselves against the tendency which leads us to establish a difference, above all, an absolute difference, between their objects.

Now, when we examine closely the idea of a sensation, and the idea of a molecular movement of the nervous centres, we

* M. de Sénarmont, Cours professé à l'école polytecknique, cité par Saigey, "La Physique Moderne," p. 216.

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find that they are acquired not only by different but by contrary ways. The first comes from within, without anything intermediate; the second comes from without, through several intermediates. To represent to one's-self a sensation, is to have present the image of that sensation, that is to say, that sensation itself directly repeated and spontaneously revived. To represent to one's-self a molecular movement of the nervous centres, is to have present the images of the tactile, visual, and other sensations, which it would excite in us, if it acted upon our senses from without, that is to say, to imagine the sensations of white, of grey, of a soft consistence, of cellular or fibrous form, of little tremulous points; it is, in short, if we go farther, to combine internally the names of movement, rapidity, and bulk, which designate aggregates and abstracts of muscular and tactile sensations. In fine, the first representation is equivalent to its object; the second, to the group of sensations which its object would excite in us. Now, we cannot conceive processes of formation more unlike. In the one case, from sense to sense, the two representations reached us by two different roads, but both external, so that nothing prevented them from starting from a common point. In the other the two representations arrive by two opposite roads, the one from within, the other from without, in such a manner that these roads continue perpetually divergent, and that we cannot conceive them to have the same point of departure. Thus the radical opposition of the two processes of formation suffices to explain the mutual irreducibility of the two representations. One and the same phenomenon, known by these two ways, will appear double, and, whatever the bond which experience establishes between its two appearances, we shall never be able to convert the one into the other. According as the representation comes from without or from within, it will appear always as *a without* or as *a within*, without our ever being able to convert the without into the within, or the within into the without.

IV.—It may be then that the sensation and the intestine movement of the nervous centres are at bottom only one and the same event, condemned, by the two modes in which it is known, to appear always and irremediably double. Another class of reasons leads to a similar conclusion. In fact, we have seen that our sensations are only compounds of elementary sensations, these again compounds, and so on; with each of these degrees of complexity the total is presented with an aspect quite different from that of its ele-

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ments; consequently the more simple its elements are, and the farther they are removed from the grasp of consciousness, the more different they must be from the total accessible to consciousness; so that the aspect of the infinitesimal elements at the bottom of the scale and that of the total sensation at the top of the scale must differ entirely. Now, such is the aspect of the molecular movements compared with that of the total sensation. Nevertheless, nothing hinders the molecular movements from being the infinitesimal elements of the total sensation. Thus the fundamental objection is removed. If our two conceptions of the mental event and of the cerebral event are irreducible into one another, that may without doubt be owing to the fact that the two events are actually irreducible into one another, but it may be owing, also, first to the fact that the event, being one, is known to us by two absolutely contrary ways, and next to the fact that the mental event and its ultimate elements must necessarily be presented to us under absolutely opposite aspects.

There is then ground, and equal ground, for the two hypotheses—for that of the two heterogeneous phenomena, and for that of one and the same phenomenon known under two aspects. Which shall we choose? If we adopt the first, we are in face of a connection, not only unexplained but inexplicable. For the two phenomena being by nature irreducible the one into the other, they form two separate, isolated worlds. We exclude by hypothesis every more general phenomenon of which they would be distinct forms and particular cases; we declare beforehand that their nature furnishes nothing which can lay the basis of their reciprocal dependence; we are then obliged, in order to explain this dependence, to seek beyond their nature, therefore beyond all nature, because they in themselves constitute all nature—consequently, in fact, in the supernatural; thus we should call a miracle to our aid, the intervention of a superior being. The philosophers of the seventeenth century, Leibniz and Malebranche at the head of them, clearly perceived this difficulty, and boldly concluded that there is a pre-established harmony, the artificial agreement of two independent clocks, an extrinsic adjustment coming from on high, a special decree of God. Nothing can be less in conformity with the methods of scientific induction; for these exclude all hypothesis which does not explain, and, as has been shown elsewhere, the principle of explanatory reason

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(*raison explicative*) is an axiom which admits of no exception.* We are then brought back to the second supposition. On the face of it it is as plausible as the first. Moreover, it has in its favour analogies and a number of precedents; for, like many other physical and psychological theories, it takes into account the play of vision, the influence of the perceiving and thinking subject, the special structure of the observing instrument. Besides this, as it does not make any third cause intervene, any imaginary or unknown property, it is as little hypothetical as possible. In short, it shows, not only that the two phenomena may be connected, but that always and necessarily they must be connected; for, from the moment that it reduces them to one, endowed with two aspects, it is clear that they are like the right and the wrong side of a surface, and that the presence or absence of the one infallibly entails that of the other. We are then authorised to admit that the cerebral phenomenon and the mental phenomenon are at bottom only one and the same phenomenon under two aspects, the one mental, and the other physical; the one accessible to consciousness, the other accessible to sense.

V.—What is the value of each of these two points of view, and what is it necessary to deduct from them in order to arrive at the true nature of the phenomenon? We have come here to the point of junction of the moral and physical world. It is from this point that the two opposite and indefinite lines which human experience travels start; the two trains thus formed advance, and separate more and more as they become more loaded at each station. We see by that the importance of the central phenomenon; whatever it be, it communicates its character to the rest. Now, of the two points of view by which we attain it, the one, which is consciousness, is direct; to know a sensation by consciousness, is to have present its image, which is the same sensation revivified. On the contrary, the other point of view, which is external perception, is indirect; it does not teach us at all as to the special characters of its object; it simply teaches us as to a certain class of its effects. The object is not shown us directly, it is denoted indirectly to us by the group of sensations which it excites or would excite in us. In itself, this physical and sensible object remains quite unknown to us; all that we know of it is the group of sensations which it provokes in us. All that we know of the cerebral

* Voir "De l'Intelligence," Livre iv., ch. iii., 553.

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molecules are the sensations of grey colour, of soft consistence, of form, of volume, and the like, that, directly, or through the microscope, in their natural state or after preparation, these molecules excite in us, that is to sav, their constant effects upon us, their fixed accompaniments, their signs, only signs, *signs and indicia of the unknown.* There is then a great difference between the two points of view. By consciousness, I attain the fact in itself; by the senses I attain only a sign. A sign of what? What is it which is constantly accompanied, denoted, *signified* by the intestine movement of the nervous centres? We have previously shown this in setting forth the conditions of sensations and images; it is the sensation, it is the image, it is the internal mental phenomenon. Henceforth everything is harmonious. This mental event which consciousness directly attains can only be attained indirectly by the senses; the senses know of it only its effects upon them; that is the reason they make us conceive it as an intestine movement of the grey cells; as it only acts upon them from without, it can only appear to them as external and physical. We see here a direct and notable confirmation of the accepted hypothesis, and we now understand why the mental phenomenon, being one, appears to us necessarily double; the sign and the event signified are two things that can no more be confounded than separated, and their distinction is as necessary as their connection. But, in this distinction and in this connection, all the advantage is on the side of the mental fact; it only exists; the physical fact is only the manner in which it affects, or might affect, our senses. For to the senses and the imagination, sensation, perception, in short, thought, is only a vibration of the cerebral cells, a dance of molecules; but thought is so only to the senses and imagination; in itself it is another thing, is defined only by its proper elements, and, if it bears a physiological appearance, it is because we translate it into a foreign language, in which it necessarily bears a character that is not its own.

H. Taine.

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