Physiology and "Vital Force."

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EFFORTS in the past to account for the mysterious powers and properties of living beings have in the main consisted of bringing in some supra-sensible, immaterial, ultra-cognisable "principle" or "entity" as the *causa causans*. This has been known under different names as time went on, but they have all referred to the same thing—psyche, pneuma, the anima sensitiva of Van Helmont, the life principle of Stahl, the Bildungstrieb of Blumenbach, the vita propria of Bordeu, the vitalis agens of Barthez, the Lebenskraft of Reil, the entelechy of Driesch, the elan vital of Bergson, and the biotic energy of Moore. It is of the essence of vitalism to explain life in terms of the less known, to account for the properties of a living being by the indwelling activity of an entity, agent, or force which, by its very metaphysical nature, is inaccessible to human investigation.

To assert that each organ, tissue, and cell is as truly alive as is the whole organism is not "vitalism," but a correct physiological observation, for the isolated organ—heart or liver—can perform its vital functions long after separation from the body to which it belonged; and the cell taken from its tissue can live for years, as Ross Harrison and Carrel have proved, in its morphological isolation. To say these organs have an independent life (whether it is said in English or in Latin *vita propria*), is to report an observation; to say that life is due to a "life force" or "entelechy" is to state a theory.

If the vitalists had always been careful to admit that their view was only a theory of life, much acrimonious discussion would have been avoided; but when they declared that theirs was the only right view, their virtual claim to omniscience failed to arouse in many minds the enthusiasm expected. These unconvinced people tried to explain life in terms of what they knew at least a little about—the non-living world around them; and they were in consequence called materialists and their theory mechanistic. Now theirs is a theory no less than is the vitalistic. The materialistic theory is that the observed known—the properties and behaviour of living organism—may be explained by applying to them our knowledge of the laws and properties appertaining to the non-living world. It is an explanation of the known in terms of the more known rather than the less.

The term "materialist" ought not to be used as one of reproach; the materialist is almost always a sincere searcher after truth, who, starting from his colleague the physicist's knowledge of the properties and behaviour of non-living matter, attempts to apply these to the behaviour of living matter. He finds that many of the laws that hold good in the world of the non-living seem to be equally applicable to that of life. In particular, he finds that vital heat, for example, is not in its essence different from heat of non-vital origin, that the great generalisation of the conservation of energy holds good for the mammalian body, that "vital" processes are accelerated by a rise, and retarded by a fall, in temperature exactly like "purely" chemical reactions in a test-tube. He is able to say in the language of his chemical colleagues 'that living

matter (protoplasm) behaves in many respects like an irreversible colloidal emulsoid hydrosol.

The materialist found, as a matter of fact, that so many vital activities seemed to be the outcome of the operation of laws already proved true for the non-living universe, that he finally made so bold as to assert—and here he made the first mistake—that the mystery had vanished, and that protoplasm, chemically speaking, was only an excessively complicated form of matter. To this view Loeb committed himself. He wished us to believe that he had proved that the dividing line between the non-living and the living had been removed, and that we might pass by a number of gradations from physico-chemical simplicity at one end of the series to great physico-chemical complexity at the other. Somewhere on the way one passed from the non-living to the living.

Here the materialist went beyond what his premises allowed him; in this he was rash; but rashness inheres in the enthusiasm of youth, and biology is a very young science. But the vitalist had always been rash for exactly the same reason; he had gone beyond experience. He had asserted that urea and sugar could never be made without the agency of life, because he had never found these substances anywhere except in living animal or vegetable tissues. When, therefore, in 1828 Wöhler made urea in a test-tube, and in the 'eighties of last century Fischer synthesised sugars, and when indigo was produced that had never seen a plant, and when the hormone adrenalin was constructed artificially, vitalism received a set-back, and materialism a corresponding encouragement. The anti-vitalistic view was further strengthened by the discovery that many ferments, solely the products of life, dealt with their "substrates" exactly like the inorganic catalysts so well known to chemists. Finally, when Loeb caused the unfertilised eggs of the sea-urchin, either by altering the density or composition of sea-water, to begin to undergo development, the days of vitalism seemed numbered.

The materialist has, indeed, shown us how the plant is able to synthesise a carbohydrate from carbon dioxide and water through the stage of formaldehyde; but he himself is very far indeed from making a scrap of nucleated protoplasm, and until he does that, since we know no life apart from nuclei, it seems exceedingly improbable that he will be able to synthesise any kind of living substance. The materialist goes far beyond his observations when he maintains that the laws of the non-living world are the only laws which operate in the sphere of the living. It is one thing for them to operate there, it is another for them to operate *alone*.

Life and living things are *sui generis*. It is better to admit at once that so far as our experience goes up to this hour, life is unique. Prof. J. A. Thomson gives the following features of the uniqueness of living matter thus (Gifford Lectures, St. Andrews, 1915-16):

1. Its capacity for enregistering experience which, in the hereditary relation, is an expression of physiological inertia.
2. The self-maintaining tendency of the organism.

3. Its variability, or the capacity to give origin to the new.

Living matter can do what no non-living matter can—assimilate material wholly unlike itself; evolve from a minute and relatively homogeneous speck into an obvious and heterogeneous organism; reproduce its kind either by casting off buds or by gametes; pass through a life-cycle of irreversible stages, from infancy to youth, maturity, senescence, and death.

So far as we can judge, the higher animals possess a variety of energy, nerve-energy, which also is *sui generis*. Finally, in the realm of the living we encounter those phenomena called subjective, the world of consciousness with all its modes—sensation, emotion, volition—a world which, so far as we know, never exists apart from living matter, and is absolutely unique.

Certain critical vitalists sometimes blame physiologists for investigating living things by the methods of chemistry and physics. The late Sir James Mackenzie wrote (*British Medical Journal*, March 1, 1924): "Physiologists place the organ in artificial conditions, employ artificial stimulation and obtain artificial results . . . such as the all-or-nothing law."

Now this criticism is rather hard to bear, because we have no methods or apparatus other than these "artificial" ones. Although the biologist is investigating phenomena that are *sui generis*, he has unfortunately no apparatus which is adapted exclusively to biological use. The physiologist uses test-tubes, retorts, induction-coils, and galvanometers because there are no two kinds of instruments, one for biologists, and one for physicists. It is rather hard that, having been forced to use these things and having by so doing obtained results valuable to medicine, he should be stigmatised as a materialist.

When we speak of the mechanism of gastric digestion, we merely use the expression as a conveniently short one for all those processes which are involved in the vital manufacture of pepsin and hydrochloric acid from neutral blood, their separation through and by the mucous membrane, and their solvent action upon food in the interior of the viscus. Nothing more "mechanical" is meant than this, and this is not mechanical at all. Only the last process, the solution of the protein, can go on *in vitro*; only life can manufacture pepsin from blood and an acid from alkaline or neutral salts, and separate these without digesting the wall of the stomach in the very act itself. It is most unfortunate that anything to do with a machine should be mentioned in this connexion.

Because the stomach "works" rhythmically and predictably we may call it a machine for turning out pepsin from blood and liken it to a machine for turning out (say) newspapers, but the secretion of pepsin is not mechanical, nor is the output of newspapers vital. Processes that closely resemble each other are not necessarily identical. In a decerebrated animal the same predictable reflex action can be obtained time after time from the same stimulus, and we may speak of the inevitableness of the mechanism of reflex arcs; but in no other sense is the spinal cord a machine.

Non-vitalistic physiologists are blamed not merely for speaking of organs and organisms as machines but

also for daring to study organs and systems by themselves, whereby, it is alleged, they have lost sight of the wonderfully co-ordinated activities of the animal as a whole.

It would seem that the physiologists can never do anything right; at a time when nothing was known of the heart, or of the liver, or of the retina, what else could the investigator do than confine his attention to one thing at a time? Some of us, indeed, are trying to take a comprehensive synthetic outlook over the whole field of vitality, but that could not have been done by the pioneers, who could only push their way slowly into an unknown territory.

One would infer from the obituary notice of the late Sir James Mackenzie in the *Times* (January 27) that physiology is bankrupt. Sir James is quoted as having said: "When this [his own view of physiology] is realised, the whole of the physiological interpretation of the functional activities of organs will have to be scrapped. This is one of the results that I anticipate."

The physiological methods by which were discovered the localisation of cerebral function, reciprocal innervation, the endocrine function of the adrenals, the thyroid gland, and the pituitary, by which insulin was isolated and adrenalin synthesised, cannot be discredited.

The experimental work of Schafer, Bayliss, Starling, Sherrington, Pavlov, MacLeod, and the Hills is not only not to be scrapped, but is also to be recognised as the logical modern basis of practical medicine. The researches that led up to electrocardiography, with which Sir James Mackenzie himself was so conspicuously associated, are another illustration. From some of his expressions the incautious reader might suppose that current physiology was useless as an introduction to medicine, and that the secret of success in diagnosis and treatment consisted in the reinstating of a "vital force." Mackenzie, writing in the *British Medical Journal* (March 1, 1924), thus expressed himself: "The reason for the lack of progress in respect of [knowledge of] living matter has been the absence of a knowledge of a vital force!" The whole tenor of this paper is that we must distrust the results of "artificial" stimulation of tissues because the effects of these are not normal, are not the same as those produced by the "vital force." The experimenter, in fact, comes under a heavy condemnation. We are further told that because we do not better understand pain and why certain reflexes occur, this "vital force" must be postulated.

The term "impulse" plays a large part in this neo-physiology. We are told: "Where a cell discharges its energy in the shape of its peculiar [particular] function, it at the same time discharges an impulse." We must know, therefore, where in the conceptual scheme of things, which has served physiology so well for the last thirty years, we can place this all-important "impulse."

As regards protoplasm three concepts are fundamental—(a) its affectability (irritability), (b) the stimulus that may operate upon it, and (c) its own response. The behaviour of a living efferent nerve may best illustrate the relations between the members of this biologic trinity. The neuroplasm, in virtue of its possessing the property of responding to a stimulus (affectability), and having received a stimulus, responds

by giving rise to an excited state which travels down the nerve as the impulse to the effector organ at the periphery, say a muscle, which twitches when the impulse impinges on it.

Let us suppose that the stimulus is a blow on the nerve, or a pinching of it, seeing that the electric stimulus of the induction coil was regarded so unfavourably by Mackenzie. Of course the existence of this impulse is an inference from what happens: a nerve receives a blow at one end and a muscle twitches at the other; something must have passed down the nerve, and that something we have for a long time called the impulse. It is said to travel down the nerve by reason of the nerve possessing conductivity.

The other indication that something is passing along the nerve is that if a galvanometer be substituted for the muscle, then when a blow is given to the nerve, the galvanometer records the presence, for a very short time, of an electric disturbance in the nerve. We infer that this electric current is an outward and visible sign of the existence of the invisible nerve-impulse. But just here a very important conclusion is reached, namely, that the impulse in the nerve on arriving at the muscle is for the muscle a stimulus to it to "contract"; the impulse in the living nerve can, then, an instant later, be the stimulus for the living muscle, the response of which is a state of shortening or contraction.

We infer that in the intact animal the nerves are conveying impulses normal or homologous, exactly similar to our laboratory ones, because if a nerve *in situ*, for example the phrenic, is connected to a galvanometer, electric currents in this case also are seen to pass through that instrument. These natural (normal) impulses must be the natural (normal) stimuli for the muscles *in situ*.

All this is very elementary; but it is evidently necessary to restate it because it accounts for everything that Mackenzie observed without calling in the aid of a "vital force" at all. We fail completely to see where and why this force needs to be invoked, and why physiology is bankrupt if it is not so introduced.

If this "vital force" is another name for the nerve-impulse—and it can scarcely be synonymous with either "stimulus" or "response"—then it is a superfluous term. If it is not a synonym for any of the three, then it is some fourth thing for which apparently there is no place in the scheme which has served biology so well in the past. The neo-physiologist may reply: it is a synonym for the nerve-impulse, but it comprehends "impulses" in all other tissues. Mackenzie's own words, in a paragraph headed, "The *impulse* a *vital force*," were: "An impulse is the product of cell-activity, it can only be conveyed by living structures and acts by stimulating cells to discharge their function . . . it differs from all other forces."

If the impulse in this passage be confined to *nerve-impulse*, no fault can be found with it, for the nerve-impulse is the product of (nerve) cell activity, it can be conveyed only by the living structures of the nerve, it acts by stimulating (muscle) cells to discharge their function (of shortening), and it differs from all other forces in that, as a nerve-impulse, it is *sui generis*. But why declare that unless we call this impulse

a "vital force," physiology is to be discredited ("scrapped").

We do not need an additional name for the nerve-impulse; if we are forced to give it a new name, why give it one so redolent of obscurantist animism (*loc. cit.*)?

It is, however, quite clear that by "impulse" Mackenzie meant something that was active in all the tissues, for he speaks of *cells* in the widest sense. Now what are these impulses in tissues other than neural? What impulses are there in muscle, connective tissue, gland, fat, bone? In muscle we have states of contraction; and we can call them "impulses" if that will rescue physiology from the scrap-heap, but one fails to see what is gained thereby. As for "impulses" in connective tissue, fat, or bone, we have no evidence of them. In glands, doubtless, some states of excitation can travel (slowly) along, but again we see no benefit from calling them "impulses."

It is difficult to see, therefore, why physiology is to be declared as proceeding on a totally wrong road. It may be frankly admitted that there is in physiology more than is dreamed of by the mechanistic philosophy. The laws of matter that has never lived have failed so far to account for certain facts, for example, about absorption both from intestine and bladder, and for certain facts about urinary secretion. It has been shown that living membranes act very differently from dead ones.

The materialistic view of life has failed signally to account for certain realities of our experience of which consciousness is the group name. Huxley himself made his bow to consciousness and waved it away as an epi-phenomenon. For the materialist, consciousness cannot be a cause of neural activity; nor can states of body affect mind, for mind is an illusion. The mechanistic theories are incapable of throwing any light on the central fact of experience, the permanence of personality amid the flux of matter.

Prof. Haldane has well said that "living" and "mind" are not reducible to simpler terms; they are the axioms of biology; and this thinker firmly believes that physiology is being retarded by mechanistic conceptions which deprive us of a complete view of life. As Prof. J. A. Thomson has said:¹ "We need new concepts such as that of the organism as a historic being which has traded with time." "We need these new concepts because there are new facts to describe, which we cannot analyse away into so-called simpler processes."

The most reasonable position to assume as regards vitalism is to insist that there is no compulsion for the biologist to be either a materialist or a vitalist. It is quite open to him to say that as he is dealing with an order of things that is unique, with existences that are *sui generis*, and that as his science is so young, he is not yet in a position to dogmatise and declare that *qua* life there are no categories beyond those the physicists and the chemists recognise.

Of all the many wise things Prof. Thomson said in his Gifford Lectures at St. Andrews (*loc. cit.* vol. 2, p. 147), this is surely one of the wisest: "We regard the question as one of the many *false dichotomies* with which man in his search for clearness has been led astray."

¹ "System of Animate Nature" (Williams and Norgate, vol. 2, p. 160).