Three Approaches to Biology: Part II. Vitalism

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Real and Imaginary Vitalism

Accounts of modern biology mention vitalism as if it were a kind of superstition which has been swept away by the advance of rational understanding. It is usually regarded as of merely historical interest, rather like the theory of phlogiston in the history of chemistry. Vitalists are portrayed as ludicrous figures clinging desparately to the belief that living organisms do not obey the laws of physics and chemistry, while the whole tide of science has flowed ever more strongly against them. The 'discrediting' of vitalism is usually said to have begun with the first synthesis of an organic chemical, urea, in the early nineteenth century, and to have been made more and more conclusive by every new discovery of physiology, genetics, biochemistry, biophysics and molecular biology.

This imaginary history forms an important part of the folk-lore of the mechanists. But in reality, vitalists did not deny that processes in living organisms took place in accordance with the laws of physics and chemistry. What they did think was that matter was organized in a special way in living organisms, which was different from that discoverable by ordinary chemistry. For example, J. C. Reil (1759-1813) held the view that "the most general attribute of the unique animal matter is a special sort of crystallization".[1] But this is not entirely unlike the mechanistic idea that morphogenesis takes place by complex spontaneous processes somehow analogous to crystallization. A typical vitalist of a later generation, J. Mueller, in

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his *Manual of Human Physiology* (1833) admitted the existence of chemicals, such as urea, governed by chemical affinities in living organisms, but thought there was also 'something else' ruling in life, namely the organizing powers of morphogenesis and movement.[2] Similar but clearer views were held by the great chemist, Liebig, who believed that although the chemist could already produce all sorts of organic substances, and would in future produce many more, chemistry would never be in a position to create an eye or a leaf. Besides the forces of heat, chemical affinity and the formative force of cohesion and crystallization, "in living beings there is added yet a fourth cause which dominates the force of cohesion and combines the elements in new forms so that they gain new qualities – forms and qualities which do not appear except in the organism"[3] (1844).

The common theme in the vitalist ideas of this period, and indeed of all periods, was that matter in living organisms is organized and controlled by specifically vital factors which do not operate in the inorganic realm. Aristotle had attributed the organizing function to the psyche, or soul, of which he thought there were three levels : in plants, the vegetative (or 'nutritive') soul, characteristic of each species, controlling morphogenesis, maintenance and reproduction; in animals, in addition to the vegetative soul, which had the same general role as in plants, there was an animal (or 'sensitive') soul, concerned with sensation and movement, controlling the animal's behaviour. In man, over and above the vegetative and animal souls, was a higher soul, that of reason or intellect. Neither in Aristotle's system, nor in any of the subsequent vitalist theories, was it ever denied that living organisms were material, that they depended on food and the physical environment, etc.; these theories simply stated, in one form or another, that in living organisms matter was *organized* by special vital factors or forces. However it was never possible to say exactly what these organizing factors were or how they worked. They were merely given names ('vis vitalis', 'vis essentialis', 'nisus formativus', etc.) and discussed in general terms.

Such vague ideas were of little use to experimental scientists, and had relatively little influence on biologists in the latter part of the nineteenth century. The mechanistic theory provided an adequate enough basis for physiological and biochemical research. But this was not the case in the field of embryology, where the difficulties of the mechanistic approach soon became apparent; it was mainly among experimental embryologists that vitalism again came to be taken seriously. The most important figure in this new development was Hans Driesch (1867-1941) who, like most pioneers in this field, was orginally inclined towards the mechanistic theory. He wrote of the change in his views as follows:

> The experiments of several years upon the power which organisms possess of regulation of form, and continued reflection on the collective results of experiments on the physiology of development, upon which I had been working since 1891, combined with a logical analysis of the concepts of 'regulation' and 'action', brought about an entire change of my opinions and the gradual elaboration of a complete system of Vitalism."[4]

The neo-vitalist movement had many other supporters and became an important force within biology, although the mechanists remained in the majority. The first two decades of this century were a period of great controversy, but by the 1930s the mechanists had achieved an almost complete dominance within the scientific establishment. Vitalism was treated as a heresy and every effort was made to stamp it out. Henceforth, almost no-one advocated vitalism explicitly; challenges to the mechanistic theory came only from the organismic philosophy. Many of these challenges were similar to those presented by the vitalists; and defenders of orthodoxy were not slow to see the organismic philosophy as vitalism in a new guise. The organismic theoreticians, on the other hand, found it necessary to disclaim any close affinity with vitalism. They claimed to have 'transcended' the vitalist-mechanist dispute.

Although vitalism is totally out of fashion, it seems worth considering what the neo-vitalists actually said. In the following sections, some of the ideas of the two most prominent, Driesch himself, and the French philosopher Henri Bergson (1859-1941) are briefly summarized and discussed. Although their most important books were written over seventy years ago, they are still extraordinarily interesting and contain insights of great originality.

Hans Driesch

Driesch's major theoretical work, *The Science and Philosophy of the Organism,* was published in 1908; a second edition appeared in 1929.

Driesch did not deny that many features of living organisms could be understood in physico-chemical terms. He was well aware of the findings of physiology and biochemistry, and of the potential for future discovery : "There are many specific chemical compounds present in the organism, belonging to the different classes of the chemical system, and partly known in their constitution, partly unknown. But those that are not yet known will probably be known some day in the near future, and certainly there is no theoretical impossibility about discovering the constitution of albumen [protein] and how to 'make' it."[5] He knew that enzymes ('ferments') catalysed biochemical reactions and could do so in test tubes : "There is no objection to our regarding almost all metabolic processes inside the organism as due to the intervention of ferments or catalytic materials, and the only difference between inorganic and organic ferments is the very complicated character of the latter and the very high degree of their specification."[6] He knew that Mendelian genes were material entities located in the chromosomes, and that they were probably chemical compounds of specific structure.[7] He thought that many aspects of metabolic regulation and physiological adaptation could be understood along physico-chemical lines[8] and that there were in general "many processes in the organism . . . which go on teleologically or purposefully on a fixed machine-like basis".[9] His opinions on these subjects have been confirmed by the subsequent advances of physiology, biochemistry, and molecular biology. Obviously Driesch was unable to anticipate the *details* of these discoveries, but he regarded them as possible and in no way incompatible with vitalism. It is, of course, these very discoveries which the mechanistic mythology treats as a conclusive refutation of his views.

In relation to morphogenesis, he considered that "it must be granted that a machine, as we understand the word, might very well be the motive force of organogenesis in general, if only normal, that is to say, if only undisturbed development existed, and if taking away parts of our system led to fragmental development."[10] But, in fact, in many embryonic systems, removal of a part of the embryo is followed by a process of regulation, whereby the remaining tissues reorganize themselves and go on to produce an adult organism of more or less normal form. The first clear experimental demonstration of regulation was provided by Driesch himself, using embryos of the sea urchin. When one of the cells of a very young embryo at the two-celled stage was destroyed, the remaining cell gave rise to an organism smaller than normal, but complete. Similarly, small but complete organisms developed after the destruction of any one, two or three of the cells of an embryo at the four-celled stage. Comparable results were obtained with other organisms, such as the newt. Many other examples of regulation of whole embryos or of embryonic organs were soon discovered. And of course the related phenomenon of regeneration, whereby damaged organs of animals or plants could be restored, was already a well-established fact.

According to the mechanistic theories of development of W. Roux and A. Weissman, in vogue in the late nineteenth century, the germ cells contained a very complicated organized structure which disintegrated during development, different parts being passed on to different cells in the process of nuclear division. In this way the structure was supposed to be broken up into its elements, each localized in a particular cell and determining its fate in the adult organism. This theory resembled the old 'preformationist' idea that the complete organism was present in the egg in miniature; but instead of a complete miniature organism there was supposed to be a structure *corresponding* to all the parts of the organism. In order to explain the facts of reproduction and regeneration, it was necessary to suppose that the complete structure was preserved in the 'germplasm' and in a 'reserve plasm' from which regeneration could originate.

Roux attempted to prove this theory experimentally. He killed one of the two cells of a frog's egg after the first cleavage and watched the development of the surviving cell. A typical half-embryo emerged, looking as if a fully formed embryo had been cut in half with a razor. This seemed to be a proof of his theory. But Driesch's subsequent discovery of embryonic regulation in the sea urchin showed that this theory could not be correct. Further research showed that although the embryos of some groups of animals behave as 'mosaics' in which the fate of the cells is fixed, as Roux had found with the frog, in other groups the embryos regulate after disturbances. But even 'mosaic' embryos were found to regulate if they were disturbed at a sufficiently early stage, and in 'regulatory' embryos the tissues would not regulate if they were damaged at a late stage; the differences were of degree and not of kind.

The fact of regulation definitively refuted this particular type of mechanistic theory. Development was thoroughly 'epigenetic': it involved the appearance of new structures and of a diversity of form which were not already organized, either in a miniature animal inside the egg, or in a complicated structure corresponding to it.

The only remaining type of mechanistic theory of development would have to suppose that it could be explained in terms of complicated physical and chemical interactions between the parts of the embryo. Driesch considered that the fact of regulation made any such machine-like system inconceivable, because the 'machine' would have to remain a whole after the arbitrary removal of some of its parts. He argued that no such physico-chemical machine is possible.[11]

It might be thought that the development of computers with complicated programmes including feedback loops provide counter-examples of regulations by machines, unknown to Driesch. But his argument holds good for computers too : no computer exists in which the whole can be automatically restored after the arbitrary destruction of parts, e.g. the smashing of all the memory discs or the ripping out of parts of the circuitry at random. Even a computer with 'back-up' circuits and duplicated parts could not survive arbitrary damage to any part of the machine, and certainly could not regenerate the missing structures. The only other item of modern technology which might seem relevant is a hologram, from which pieces can be removed but which can still give rise to a complete three-dimensional image. But the image produced in thin air from a hologram is not by any stretch of the imagination a machine-like material structure capable of carrying out characteristic functions. In any case, the hologram cannot give rise to any image by itself, but only when it is part of a set-up including a laser, mirrors, etc. If a part of this functional whole, say the laser, is destroyed, obviously the remaining parts are unable to regulate and produce a new laser.

While no actual machines exist which have the power of regulation or regeneration after arbitrary removal of parts, it might be thought that such physical or chemical machines could one day be invented. But Driesch argued that they cannot even be conceived. And, so far, they have not been conceived. This is a powerful argument, but mechanists could always escape by saying that they could be conceived at some time in the future. However, this would be a poor defence, lazy and evasive.

Driesch's second refutation of the mechanistic theory was very simple : no complicated physico-chemical machine, typically different in the three dimensions of space, could be divided into parts which still remain wholes. Yet this is what happens in reproduction : parts of a parent organism become detached from it and give rise to new organisms. No self-reproducing physico-chemical machine actually exists. If mechanists were to argue that it could be conceived in principle, then to resemble a living organism it would also have to have the power of regulation. Such a physico-chemical system defies imagination.

His third refutation was based on the analysis of behaviour and learning, in which the stimuli and responses on the basis of experience cannot be analysed into simple parts, but are wholes.

The essence of all these arguments is that machine-like systems are composed of an aggregate of parts and do not possess the properties of 'wholeness' which are exhibited by living organisms. Driesch considered that these refutations of the mechanistic theory proved that, in addition to the laws of physics and chemistry, another causal factor must be operating in living organisms. He called this factor 'entelechy', and suggested that it organized physico-chemical processes during morphogenesis, and controlled the actions of animals through its influence on the brain. The genes were responsible for providing the material *means* of morphogenesis

—the chemicals to be ordered—but the ordering itself was brought about by entelechy. Similarly, the nervous system provided the means for action, but entelechy organized the activity of the brain, using it as an instrument, as a pianist plays upon a piano. Clearly, development and action could be *affected* by changes in the genes or by damage to the brain, but they could not be *explained* simply in terms of genes and nerves. The mechanisms of a piano are not a sufficient explanation for the music played on it, although they are a necessary means. Damage to the piano, e.g. by severing some of the strings, affects the music which the pianist can produce, but this does not prove that the music is fully explained by the mechanisms of the piano.

Entelechy is a Greek word whose derivation (*en-telos*) indicates something which bears the end in itself; it contains the goal towards which a process under its control is directed. Thus if the normal pathway of development is disturbed, the same goal may be reached in a different way, a phenomenon that Driesch terms equifinality. He considered that development and behaviour were under the control of a hierarchy of entelechies, which were all ultimately derived from, and subordinated to, the overall entelechy of the organism.[12] As in any hierarchical system, such as an army, mistakes were possible and entelechies might behave 'stupidly', as they do in cases of super-regeneration, when a superfluous organ is produced.[13] But such 'stupidities' do not disprove the existence of entelechy any more than military errors disprove that soldiers are intelligent beings.

Driesch described entelechy as an 'intensive manifoldness', a non-spatial causal factor which nevertheless acted into space. He emphasized that it was a natural (as opposed to a 'metaphysical' or 'mystical') factor which acted on physico-chemical processes. It was not a form of energy, and its action did not contradict the second law of thermodynamics or the law of conservation of energy. Then how did it work?

Driesch was writing during the era of classical physics, when it was generally considered that all physical processes were fully deterministic, in principle completely predictable in terms of energy, momentum, etc. But he thought that physical processes could not be fully determinate, since it would otherwise be impossible for the non-energetic entelechy to act upon them. He therefore concluded that, at least in living organisms, microphysical processes were not fully determined by mechanical causality, although, on average, physico-chemical changes obeyed statistical laws. He suggested that entelechy acted by affecting the detailed *timing* of microphysical processes, by 'suspending' them and releasing them from suspension whenever required for its purposes:

> This faculty of a temporary suspension of inorganic becoming is to be regarded as the most essential ontological characteristic of entelechy . . . Entelechy, according to our view, is quite unable to remove any kind of 'obstacle' to happening . . . for such a removal would require energy, and entelechy is non-energetic. We only admit that entelechy may set free into actuality what it has *itself* prevented from actuality, what it has suspended hitherto.[14]

This seemed to be the greatest weakness of Driesch's system. To scientists at that time, any interference with physical determinism was unthinkable, and so Driesch's idea seemed impossible in principle.

It is surely ironic that at the time when vitalism seemed to the majority of biologists to have been finally discredited, undreamt of changes were occurring within physics. Heisenberg deduced the uncertainty principle in 1927; it soon became clear that the positions, energies and timings of microphysical events could be predicted only in terms of probabilities. By 1928, an eminent physicist, Sir Arthur Eddington, was able to speculate that the mind influences the body by affecting the configuration of quantum events within the brain through a causal effect on the probability of their occurrence : "Unless it belies its name, probability can be modified in ways which ordinary physical entities would not admit of."[15]

Comparable ideas have been proposed by the neurophysiologist Sir John Eccles, who summarized his hypothesis as follows:

> The 'will' modifies the spatio-temporal activity of the neuronal network by exerting spatio-temporal 'fields of influence' that become effective through this unique detector function of the active cerebral cortex. It will be noted that the 'will' or 'mind influence' has itself some spatio-temporal patterned character in order to allow it this operative effectiveness.[16]

More recently, a number of similar but more detailed proposals have been made by E. H. Walker,[17] and certain other physicists.[18] Needless to say, these suggestions are very controversial; but the mere fact that they are possible indicates how much physics has changed since Driesch's day. So although Driesch's ideas still seem very radical, it is no longer possible to dismiss them *a priori* on the grounds that physical processes are fully determinate.

Henri Bergson

Bergson's most important books were *Matter and Memory* and *Creative Evolution*, first published (in French) in 1896 and 1907 respectively. The former is about the relation between the mind and the body, and the nature of consciousness. Bergson accepted that there was a close connection between states of consciousness and the brain:

> But there is also a close connection between a coat and the nail on which it hangs, for, if the nail is pulled out, the coat falls to the ground. Shall we say, then, that the shape of the nail gives the shape of the coat, or in any way corresponds to it? No more are we entitled to conclude, because the psychical fact is hung on the cerebral state, that there is any parallelism between the two states, psychical and psychological.[19]

Having rejected the mechanistic theory, Bergson came to a number of astonishing conclusions, only one of which need be mentioned here: memory is not material, and is not stored physically or chemically within the brain; the brain is not a 'reservoir of images'.

At first sight this idea seems quite impossible. The mechanistic theory has come to be taken for granted, and it is difficult to free one's-self from its presuppositions. Yet Bergson's arguments are far from being illogical or absurd. He shows a way out of the insoluble paradoxes associated with a mechanistic view of consciousness, and provides the outlines of a totally new understanding of some of the perennial problems of philosophy. The radical difference between his ideas and those of orthodoxy can perhaps be illustrated by means of an analogy.

Imagine once again an ingenious artisan who knows nothing about electricity or the principles of radio, but who is convinced that a radio set can be fully explained in terms of the properties of its physical components. The voices that come from the loudspeaker seem to be produced within the radio set and to be entirely a product of microscopic mechanical changes within the wires, transistors, etc. The artisan finds that if he removes certain components of the set, certain voices are no longer produced (say all those on the long-wave band). He concludes that the voices were actually located within the components he removed. In fact, of course, they come from various radio stations; the removal of certain components merely prevents them from being received by the set. The radio broadcasts are still there even if the set cannot detect them. Similarly, memories can act upon the brain when it is 'tuned' to them, but they are not stored inside it. Damage to certain regions of the brain prevents certain types of memory from acting, but this does not prove that the memories are physico-chemical structures localized within the nervous tissue. The orthodox view of the brain and its functions represents as great a misunderstanding as that involved in thinking that radio sets contain voices and music, or that television sets contain the miniature people whose images appear upon the screen.

Bergson did not explain where memory was, if it was not inside the brain, or how it acted on the brain. In Driesch's system memory was regarded as acting on or through entelechy.[20] But this hardly solved the problem, since so little could be said about the nature of entelechy.

In *Creative Evolution*, Bergson argued that purposeful structures such as the eye could not have evolved mechanistically simply through a combination of random mutation and natural selection. He rejected a Lamarckian explanation in terms of an inheritance of acquired characteristics, and also dismissed the idea that evolution proceeds towards a goal and is directed by some fixed transcendent plan or design. Instead, he thought that the current of life, flowing from generation to generation, was the result of an original 'vital impetus', the 'élan vital'. "This impetus, sustained right along the lines of evolution among which it gets divided, is the fundamental cause of variations, at least of those that are regularly passed on, that accumulate and create new species. In general, when species have begun to diverge from a common stock, they accentuate their divergence as they progress in evolution. Yet, in certain definite points, they may evolve identically; in fact, they must do so if the hypothesis of a common impetus be accepted."[21] Thus Bergson used this rather obscure concept to account for evolutionary creativity, for apparently directed lines of evolution ('orthogenesis') and for the evolution of very similar organs in more or less closely related groups of organisms. He thought that this same impetus revealed itself not only in the evolution of form, but also in the evolution of instinct, and in the evolution of intelligence. By tracing the latter, and by seeing in terms of a general theory of life, he hoped that it would be possible to arrive at a deeper understanding of knowledge itself. He did not claim to have solved the new problems he raised; rather, he was attempting "to define the method and to permit a glimpse, on some essential points, of the possibility of its application."[22]

The Eclipse of Vitalism

The theories of Driesch, Bergson and the other neo-vitalists were far from complete: they represented only the beginnings of an attempt to replace the mechanistic paradigm, and to open the way to a new system of biology. This new biology would have included physico-chemical investigations of living organisms, but would also have aimed to find out in as much detail as possible exactly what the 'vital factor' was and how it worked;it would have encouraged all lines of investigation which might have helped in this quest, rather than ruling out any of them *a priori*. It is significant that both Bergson and Driesch served as Presidents of the Society for Psychical Research (in 1913 and 1926-27 respectively).

But the vitalist revolution aborted, for at least three reasons. First of all, the concepts of vitalism were very vague, and raised many problems which could not be solved immediately. This has been true of most new systems in science from the time of Copernicus onwards, and is always a disadvantage in the face of an established orthodoxy. Secondly, the vitalist ideas suggested no new types of experiment; there seemed to be nothing that could be done to test them in the laboratory. By contrast, there were countless physico-chemical problems which biologists could get on with the job of studying; and they could do this perfectly well on the basis of the mechanistic theory. Thirdly, vitalism was radically incompatible with the determinism of classical physics.

The orthodox view of vitalism is, of course, that it has been rendered ever less tenable as mechanistic biology has advanced. In the words of the influential molecular biologist, Jacques Monod : "Developments in molecular biology over the last two decades have singularly narrowed the domain of the mysterious, leaving little open to the field of vitalist speculation but the field of subjectivity: that of consciousness itself."[23] But this is just not true. Consider Driesch's system, which was not based on any speculations about subjectivity in the first place. The discoveries of molecular biology were, in general terms, anticipated by him. Morphogenesis, which was central to his argument, has not begun to be explained mechanistically; regulation and regeneration are as mysterious as ever they were; molecular biology has shed no light on instinct and learning; no physico-chemical basis of memory has been discovered. In fact, the passage of over half a century has strengthened, rather than weakened, the vitalist case. Mechanistic biology has failed, despite enormous efforts, in exactly those areas where the vitalists said it would fail. If vitalism has been superseded, it is not because of any of the discoveries of modern biology, but because of the development of the organismic philosophy. Organicism is more radical than vitalism in that it challenges the entire atomistic philosophy of nature, of which the mechanistic theory of life is only one aspect. Organicists advocate a non-reductionist approach not only to biology, but to physics and chemistry as well.

Notes

1. Quoted in H. Driesch: *History and Theory of Vitalism*, p. 99. Macmillan, London (1914).
2. ibid, p. 114.
3. ibid, p. 119.
4. ibid, p. 177.
5. H. Driesch: *The Science and Philosophy of the Organism* (second edition), p. 290. Black, London (1929).

6. ibid (first edition, 1908), Vol. 1, p. 203.
7. ibid (second edition), pp. 152-154, 293.
8. ibid, pp. 135, 291.
9. ibid, p. 246.
10. ibid, p. 103.
11. Some *simple* inorganic systems remain 'wholes' after the removal of parts; for example the parts of a magnet remain whole magnets; and a drop of water split into two gives two whole drops. But these systems are not characteristically different in three dimensions of space: a magnet is effectively two dimensional, and a drop of water is radially symmetrical. To exclude such cases Driesch qualified his statement as follows: no complicated physico-chemical machine with a structure that differs characteristically in the three dimensions of space can remain a whole after the arbitrary removal of parts.
12. *The Science and Philosophy of the Organism* (second edition), p. 246.
13. ibid, p. 266.
14. ibid, p. 262.
15. A. Eddington: *The Nature of the Physical World*, p. 302. Dent, London (1935).
16. J. C. Eccles: *The Neurophysiological Basis of Mind*. Oxford University Press, Oxford (1953).
17. E. H. Walker: Foundations of paraphysical and parapsychological phenomena. In: *Quantum Physics and Parapsychology* (ed. L. Otera). Parapsychology Foundation, New York (1975).
18. E.g. J. H. M. Whiteman: Parapsychology and Physics. In: *Handbook of Parapsychology* (ed. B. B. Wolman). Van Nostrand Reinhold, New York (1977).
19. H. Bergson: *Matter and Memory*, p. xv. Allen and Unwin, London (1911).
20. *The Science and Philosophy of the Organism* (second edition), pp. 229-230.
21. H. Bergson: *Creative Evolution*, pp. 92-93. Macmillan, London (1911).
22. ibid, p. xiv.
23. J. Monod: *Chance and Necessity*, p. 37. Collins, London (1972).