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## DISCUSSION

### MECHANISM AND BIOLOGICAL EXPLANATION\*

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#### I

Machines and Biology have been, since antiquity, closely related. From the zoological figures present in astronomical simulacra, through renaissance mechanical imitations of animals, through Decartes' wind pipe nerves, to present day discussions on the computer and the brain, runs a continuous thread. In fact, the very name of *mechanism* for an attitude of inquiry throughout the history of Biology reveals this at a philosophical level ([4] and [6]). More often than not, mechanism is mentioned in opposition to vitalism, as an assertion of the validity of the objectivity principle in biology: there are no purposes in animal nature; its apparent purposefulness is similar to the purposefulness of machines. Yet, the fact that one picks machines as a set of objects comparable to living systems, deserves a closer look. What in machines makes it possible to establish such a connection?

#### II

If one is to have an understanding of a given class of machines, it is obviously insufficient to give a list of its parts or to define its purpose as a human artifact. The way to avoid both insufficiencies is to describe the permitted interrelations of the machine components which define the possible transitions that the machine can undergo. This, on the one hand, goes beyond the mere listing, and on the other, implies the nature of the output that determines the purpose of the machine. Notably, when looking at the components not all of their properties have equal importance. If one is to instantiate or construct or implement a certain machine, then, in choosing the components, one would take into account only those component properties that satisfy the desired interrelations leading to the expected sequence of transitions that constitutes the machine description. This is tantamount to saying that the components might be any components at all *as long as their possible interrelations satisfy a given set of desired conditions*. Alternatively, one can say that what specifies a machine is the set of component's interrelations, regardless of the components themselves. We call this the *structure* (or *theory*) of the machine.

We are thus saying that what is defintory of a machine structure are relations and, hence, that the structure of a machine has no connection with materiality, that is, with the properties of the components that define them as physical entities. In the structure of a machine, materiality is implied but does not enter *per se*. A

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Turing machine *is* a certain structure; there seems to be a hopeless gap between the way in which a Turing machine is defined and any possible instance (electrical, mechanical, etc.) of it. This has been pointed out by workers in the field of Cybernetics. As Ashby puts it:

the truths of Cybernetics are not conditional on their being derived from some other branch of science . . . (They) depend in no essential way on the laws of physics or on the properties of matter . . . The materiality is irrelevant, and so is the holding or not of the ordinary laws of physics. ([1], p. 1)

Also,

since the distinction between 'open for energy' and 'closed for information and control' implies the irrelevancy of the material aspects of cybernetic system, one might describe cybernetics from the ontological angle as the study of a specific type of a system that must be described in terms presuming but not designating the materiality of the system. ([5], p. 332)

We believe Wiener was pointing to this when he emphasized "information, not matter or energy. No materialism which does not admit this, can survive at the present day" ([11], p. 132).

There are several other situations where a similar disjunction between materiality and structure appears. Take for instance symmetry. One clearly has empirical examples of symmetry. Yet, one can formulate a theory of it in which materiality concepts do not enter at all. Still it is possible to transport this theory with no modification to a different context where materiality does appear, as in particle physics. Certainly several other examples exist.

### III

The objection might arise that the notion of structure that has been developed above, belongs to a more inclusive field, that of mathematics. This objection, however, carries no weight because the explanatory value of the notions under discussion correlate with empirical circumstances, artificial or natural, that embody them. Thus, there is the reality of symmetry of natural objects and there is the mathematics of symmetry. Similarly, there is the reality of magnetism and there is the mathematics of magnetism. They do not superimpose, but one embodies the other. From this point of view there is no difference between physics and, say, Cybernetics. What makes physics peculiar is the fact that the materiality *per se* is implied; thus, the structures described embody concepts which are derived from materiality itself, and do not make sense without it. Despite any advances, in physics one is looking at the structure of materiality. Whether these basic structures are subsumed in self-fields or similar constructs is of no import to our argument (see, for example, [8]).

Furthermore, there are no differences in the explanatory paradigm used in the formulation of, say, atomic theory or control theory. In both cases we are dealing with an attempt to reformulate a given phenomenology in such terms that its

components are causally connected. Yet, in one case the notions are directly related with materiality; while in the other case, materiality does not enter at all.

We thus believe that the classical distinction between synthetic and analytic should be refined. Within the synthetic one should distinguish two levels: the *materially* synthetic (i.e. where materiality enters *per se* into consideration), and the *nonmaterially* synthetic (i.e. where materiality is implied but is, as such, irrelevant).

#### IV

In this light, one should look closely at the consequences of the basic assertion for biological mechanism: living systems are machines of one or several well-defined classes. This is to say: the definitory element in the living organization is a certain structure (the set of interrelations leading to a given form of transitions) independent of the materiality that embodies it; not the nature of the components, but their interrelations. There are three main consequences of this assertion:

- (1) Any explanation of a biological system must at least contain two complementary aspects one referring to it as a structure and the other referring to it as an instance. The first must account for the specific dynamic configuration of components that define it; the second must account for how its particular components enter in the given interrelations that constitute it.
- (2) Any biological system can be treated in terms of the properties of its actual components as a physical system. There is no limitation whatsoever in doing so, except for the number of variables that one might have to consider. But this is only a problem in computation. Eventually, one should be able to have a physical description as accurate as needed of any biological system. Although such an analysis is insufficient, it is necessary to point to the specific structure(s) of biological systems, making it possible to make sense out of a given form of interrelations.
- (3) Insofar as the physical analysis of biological systems is still physics, what is specific of Biology is precisely the analysis of the class of machines that living systems are, and the changes that these undergo in time. Thus, the specific aspects of any biological explanation belong to the second level outlined above, and are necessarily not deducible from physics. In this sense, Biology is not reducible to physics, (although the explanatory paradigm is the same as noted in 3). Reduction is used here to mean a program which would make it eventually possible to derive Biology from Physical Chemistry, in order to produce a unified science. (See [7] and [9]).

#### V

We wish to conclude by making some remarks on what seems to us to be a persistent error in the philosophy of biology: the alleged specificity and necessity of function and teleology in biological systems (cf. [10]).

When considered in the light of a machine structure as described above, function and teleology acquire different characteristics. The purpose (teleology) of a machine is always related to its output through an external observer which correlates this output with himself. As it has for long been known, it suffices to consider the structure of the machine, of which the output is only a consequence, to make any reference to purpose unnecessary—unless it be for heuristic reasons.

More interestingly with function: in saying that a function of  $P$  is  $\phi$  we must pay closer attention to the character of  $\phi$ . Indeed, it must be something like: "circulation," "support," etc. All these notions suppose a larger conceptual scheme (see [2], [3]) which is more embracing: circulation *in* something, support *of* something. A functional description necessarily includes a larger context to which  $\phi$  makes reference.

Conversely, for every structure or theory, one can point to a substructure and describe its performance in the form of a functional description. Consider:

- $S_1$ : The function of the electron shell is to balance the nuclear charges.
- $S_2$ : The electron shell balances the nuclear charges.
- $T_1$ : The function of DNA is to code for proteins.
- $T_2$ : DNA codes for proteins.

What are the differences in these sentences? We interpret them as follows: In the case  $S_1$  one is making reference to a perfectly defined structure, the atom, for which we have already an explicit formulation of its theory. Thus, although  $S_1$  is comprehensible, it is totally dispensable in favor of  $S_2$ , which is a statement that can be interpreted as a mere consequence of the total structure. For the second set, the dispensability of  $T_1$  in favor of  $T_2$ , although thinkable, seems much less clear. This arises because the sentences refer to a system which is included in a much larger one, the cell. One can certainly treat protein synthesis as an isolated system (i.e., in an *in vitro* experiment), but in the cell its condition of subsystem makes possible its functional description. Thus a functional description, when not dispensable, is symptomatic of the lack of a theory for the structure of the system in which the subsystem, described in functional terms, occurs.

In general, we believe that the very common occurrence of functional descriptions in biology is in relation to the fact that normally the systems studied are subsystems of more inclusive ones. Within a given subsystem, considered isolated, functional descriptions disappear or are dispensable. Similarly, the dispensability of functional description is possible when the structure of the system at large, with no possible further extensions, is given, and subsystems become consequences of the general structure, as in the case of the atom mentioned above, or of any well-defined machine. Thus we do not talk about the function of the state  $q_x$  of a Turing machine, except for pedagogical purposes.

It must be clear, however, that the communicative value of a functional description is not eliminated by the detailed material analysis of it as a particular instance. Clearly, the material analysis will make possible and modify the precision of the functional description, but will not eliminate its communicative value simply because it does not depend on it.

To envision living systems as machines is to point to their structural condition independent of materiality. To find that in the analysis of such machines functional descriptions occur frequently, and that it is not yet comfortable to dispose of them as explanatory devices, indicates the lack of a theory of the kind of machines living systems are. Only with such a theory will function lose its alleged explanatory value, and retain its value as a communicative tool.

## VI

We have attempted to show that it is important for the formulation of adequate biological explanations to distinguish a synthetic level where materiality does not enter *per se*. Machine analysis belongs to this level, and if one is to follow a mechanistic outlook to its last consequences such a level of analysis reveals what is specifically biological. The structure of living systems and their actual (material) components are complementary yet distinct aspects of any biological explanation: they complement each other reciprocally but cannot be reduced to one another.<sup>1</sup>

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