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TELEOLOGY IN MODERN BIOLOGY

The use of teleological explanation in biology is examined and shown to be compatible with causal explanation. Teleological relations are just as objectively and empirically discernible as causal relations.

Introduction

Etymologically 'teleology' implies 'the study of ends'; and the word is used to designate the attempt to explain objects and events in terms of their aims or the purposes they serve. Teleological explanation, like causal explanation, can be offered only with respect to orderly systems, and orderly systems occupy both time and space. Although both temporal and spatial relations are always present, it is sometimes the former and sometimes the latter which are more significant in determining the aim or purpose of a part of a system. Thus when an important building, intended to last for a long time, is erected it may have a few contemporary artefacts (e.g., coins, documents) buried in the foundations. A teleological explanation of the presence of the artefacts will chiefly involve the temporal relations (with future generations of historians or archaeologists) whereas a teleological explanation of the presence of the foundations will be mainly concerned with spatial relations (with the direction of gravitational force, the substrate, and the superstructure). A teleological explanation of an object or event may therefore relate either to some future outcome of its occurrence or to its relation at the particular time to the whole system of which it forms a part, or to both. In contrast, a causal explanation either relates to some antecedent condition or else explains the whole in terms of its parts, or does both.

Teleological explanations differ therefore from causal explanations in two important respects: to put them crudely, teleology explains the present in terms of the future, whereas causality explains the present in terms of the past; teleology explains the part in terms of the whole, while causality explains the whole in terms of its parts.

The use of teleology has traditionally stemmed from two sources:
(a) man's awareness of aims and purposes in human activities (this has often uncritically been extended by analogy to animal behaviour), and
(b) the Biblical teaching that the universe has been created, and is continuously maintained, by a divine Creator who works purposefully, so that the parts of the universe were seen as designed to fulfil God's purposes.
It was this concept of design that explained the beautiful adaptations of organisms to their environments, that figured so prominently in former Christian apologetic works.

With the widespread acceptance of the Darwinian theory of natural selection it became possible, at least in principle, to explain the same adaptations causally. Furthermore, the growing awareness of the importance of objectivity and empiricism in scientific description led to the abandonment by biologists of the use of subjective experience of animals in explaining directive behaviour. Thus the two foundations of teleology in biology were undermined; and by the 1920s and 1930s it had become fashionable for biologists not just to ignore but rather to denounce, at times passionately, teleological description in their science. Since then teleology has been professedly taboo.

Despite this, biologists, when chatting informally, still frequently use blatantly teleological language; and, even when on their best behaviour (e.g. when writing research papers or textbooks), they use expressions such as 'adaptive significance' and 'function' which, although not traditional teleological expressions, frequently seem to amount to the same thing.

It is the purpose of this paper to discuss (a) the validity and (b) the value of such teleological description in modern biology.

Is Teleological Description Objective

All branches of biology afford numerous examples of structures and processes that *appear to be* purposive.

To quote just a few:

(a) Most, if not all, animals, if they are to remain healthy, require that a number of internal physiological variables (e.g., concentration of glucose, osmotic pressure, etc., of blood) shall remain within narrow limits. Any departure from the norm brings into operation negative feedback mechanisms (often highly complicated and 'multichannel') which restore normal conditions.

(b) Many aquatic animals, freshwater and marine, leave their normal feeding grounds and migrate upstream during the breeding season to new areas where they shed their eggs. The eggs and probably, later, the newly-hatched larvae are then carried back in the opposite direction until, by the time they are ready to settle down in life, they are in the general area formerly occupied by their parents. But for this parental migration, the young would find themselves in areas far removed from the ancestral home and probably quite unsuitable for them.

(c) When the fertilized egg of a newt begins its development it divides into two daughter cells, which then divide and redivide to produce the millions of specialized cells that constitute the adult body. In the normal course of events each of the two original daughter cells gives rise to one side of the adult body. If, however, they are experimentally separated it is found that each can give rise to a whole adult. Manipulation of the early developmental stages of other forms has shown that very many species of animals exhibit adjustments in their development such that, despite the experimental interference, a normal adult body is produced.

(d) The heart of a vertebrate undergoes continuous pulsating contractions, coordinated with movements of its valves, in such a way that blood is pumped out of the heart, along the arteries to all parts of the body, and back again via the veins to the heart.

In outlining these examples I tried to be completely objective and to avoid teleological language; but I found this difficult. In fact, in my first draft, I wrote that some aquatic animals 'migrate upstream to lay their eggs' without realizing what I had said. It would similarly have been very easy to say that the dividing egg cells can adjust their activities *in order to* ensure, as far as possible, the development of a normal adult; or that homeostatic mechanisms are stimulated by abnormal physiological conditions *in order to* control them; or that the parental migration is *for the purpose of* facilitating the offspring's finding of a suitable niche; or that the heart beats *in order to* maintain a transport current to all parts of the body. It is this sort of teleological language which is conventionally frowned upon; although I find it difficult to identify any difference in principle between it and such generally acceptable expressions as 'the adaptive significance', 'the survival value', and 'the biological function' of a structure or process. If we talk about the adaptive significance, for example, of something we are discussing, we mean the way in which that thing meets some need which an organism has if it is to survive in its normal environment. In other words, we are talking about the purpose it serves in the life of the individual or the species — and what is that if not teleology?

Is this teleological explanation objective, i.e., based upon empirical evidence? Let us consider first the type of teleology in which the temporal relations are the significant factor, as in examples (a) - (c) above. That there is a correlation between a process and its suspected goal can be determined in the same way as a causal correlation can be recognized — by observation of the regular succession of one by the other. That the relation is a purposive one can be recognized by such consistent features as the persistence of the process until the goal is achieved, its cessation thereafter, the adaptability of the routes by which the goal is reached, and the presence of feedback mechanisms brought into operation by deviations from the end-state. These are all objective features which do not depend for their recognition upon the concept of design or of subjective awareness. (It is for this reason that some writers prefer the word 'directive' to the word 'purposive' which may have psychological overtones.)

The second type of teleological explanation is that which relates the function of a part to the functioning of the whole system, as in example (d) above. To discuss this, let us consider an analogy — the workings of a watch (in true Paleyan tradition). It would be possible for an imaginary engineer, who knew nothing about the purpose of a watch, having examined it and performed a few simple experiments (e.g., turning the winding button), to give, not only a causal explanation of the functioning of the whole watch in terms of its parts, but also a teleological explanation of the parts in relation to the whole watch. Thus the mainspring could be described as the energy store for the watch, the balance wheel/escapement complex as the device for regulating its rate of activity, and the case as a protective structure. On the other hand, unless the engineer knew something about the purpose of the watch, or about the conventional division of time into hour and minute units, he could not give a teleological explanation of the dial and the hands. Now his ability to give a teleological explanation of, at least, some of the parts depends upon the fact that the watch is recognized as an orderly system. If all the same parts were dropped separately into a pudding basin, our observer, having examined the collection, would be quite unable to offer a teleological explanation of them, because the whole would not constitute an orderly system.

Orderly systems can be recognized by the use of objective criteria, such as regular relations between their parts, regular relations between the parts and the whole, regular relations between input and output, and similarity between these relations and corresponding relations in other systems of the same kind. If tested against these criteria living organisms and societies are undoubtedly found to be orderly systems; and it is this fact which permits the possibility of this type of teleological explanation in talking about the functional significance of, say, chromosomes, liver cells, hearts, nervous systems or queen bees.

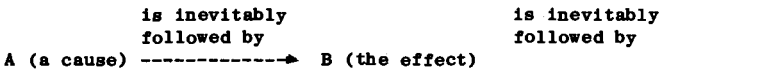
The Relation Between Causal and Teleological Explanation

Objections have sometimes been raised to teleological explanations on the grounds that an event does not always achieve its purpose (as in the sad tale of Old Mother Hubbard), so that one has the anomaly that the same explicandum that normally has a teleological explanation may on occasions completely lack one. This objection appears to rest on the assumption that a teleological explanation is a sort of causal explanation in which the cause follows the effect instead of preceding it. It is actually nothing of the sort.

Even if Old Mother Hubbard had been successful in finding a bone for her dog, in no way could her finding of the bone be regarded as a cause of her locomotion to the cupboard. On the other hand, the possibility of finding a bone does give *significance* to the locomotion, whether the possibility is actually realized or not. Obviously if a bone has to be found, the lady's going to the cupboard will greatly enhance the probability of its discovery, although as we have seen it cannot guarantee it. A teleological explanation of an event, then, depends upon the correlation of that event with some other event (normally beneficial) which it will facilitate, although not guarantee. Now this facilitation may or may not involve a direct causal relation. In the case of the newt egg it does: the separation of the two daughter cells itself induces the modified development of each. In the case of the spawning migration it does not: the migration itself does not induce the spawning, nor, of course, does the parents' behaviour 'cause' the downstream carriage and settlement of the larvae. In fact, the migration and spawning are, more often than not, both consequences of some other factor or factors, e.g., increasing day-length in the spring, internal endocrine changes.

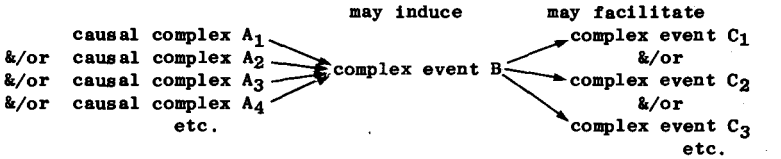
Now I have tried, not completely successfully, to avoid the use of the word 'cause', because if one accepts the usual philosopher's definition of it — a necessary and sufficient condition — the word is virtually of no use to the biologist. He is dealing with such complex systems that it is usually impossible to identify the cause thus defined. The nearest that the biologist gets to identifying cause and effect is to be able to specify complex events that are usually followed by other complex events. The concept of causality is, of course, valid; but the biologist (if he ever thinks about it at all) soon realizes that it is *practically* impossible to identify in the causal complex the one necessary and sufficient condition of the one effect in the effect complex.

In the philosopher's ideal situation where



B would have a causal explanation (the presence of A) and, if C were in some way biologically valuable, possibly a teleological explanation (it produces the useful C) in addition; and the causal and the teleological explanations would be logically related, because both the cause A and the biological significance (the causation, not just the facilitation, of C) could be inferred from the event B.

But, as has been said, this ideal state of affairs does not exist in biology. Instead the biologist has to contend with something like the following:



In these circumstances, the biologist observing complex event B could not logically infer which of the many possible causal complexes (A) had occurred, nor could he specify which of the possible complex events (C) facilitated actually achieved its goal. To this extent causal and teleological explanations are, in practice, logically independent (although not in different logical categories, and therefore not complementary).

Let me illustrate this abstract rigmarole with a concrete example. Seals and sea lions are born on land where for some time they are suckled by the mother. Sooner or later, depending on the species, they move into the sea where (and only where) they can feed themselves, learn to swim, and prepare themselves by play for the responsibilities of adulthood. This movement into the water can be explained causally and teleologically in several possible ways: causally — the animal may have been pushed into the water by its mother, it may have fallen into the water off a rock, its exploratory behaviour may have taken it into the sea, it may have fled there from a hunter, and so on; teleologically — the movement is of biological significance in that it facilitates such useful arts as swimming, feeding, and playing. It will be seen that the causal and the teleological explanations are logically independent in that the particular causal explanation is irrelevant to the

consequences facilitated. It will be noted too that both explanations are within the framework of the concept of causality: even the teleological explanation depends upon causal facilitation of consequences that are recognized as biologically valuable on a causal basis (e.g., feeding provides energy necessary for life). Nothing has been said about the animal's volition or intentions or of God's plan of creation: we have crossed the boundaries of no logical categories.

The Implications of Biological Teleology

So far I have argued that teleological explanation depends upon the recognition of a regular relation between the explicandum and some biologically valuable consequence which it facilitates.* But how is this correlation to be understood? It could mean no more than the explicandum *normally leads to* the goal; or it could mean that the explicandum is *in order to lead to*, or is *for the purpose of leading to*, its goal.

Consider an analogy. If a tennis ball were accidentally to fall into a water tank it would bob up and down at the water surface until it came to rest at a particular level: if it were momentarily pushed down it would repeat the process. In an analogous fashion a thermostatically controlled heater in the tank would have its heating current switched on and off thus tending to maintain a particular temperature level. Both of these would be goal-directed systems; but of the first we should say only that its behaviour *normally leads to* the goal, while of the second we could say quite correctly that its behaviour is *in order to lead to* the goal. Why the difference? In the first case the relation of ball to water is purely fortuitous; but in the second the thermostatically controlled heater had been selected and installed because it was capable of achieving a valuable goal.

Is there then anything in nature equivalent to this selection and installation of a goal-directed system? The Darwinian theory of evolution suggests that there is. Random mutations in the past have produced in organisms all sorts of novel structures and processes, most of which, no doubt, were, like the tennis ball, of no value or positively harmful. Their possessors would stand less chance of surviving and reproducing, and the novelty would be eliminated. Occasionally, however, a biologically valuable mutation has occurred, giving the mutated form better chances of survival and reproduction, and this novelty has therefore been

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* Perhaps it should be pointed out that to recognize something as having biological value is not to make a traditional value judgement: a thing is of biological value if it facilitates survival of an individual or a species. Nothing is implied about whether it *should* survive or not.

selected and 'installed' in the species. In this way natural selection is similar to the role of the heating engineer who installed the heater in the tank — and would probably also remove the tennis ball if he found it there. If this theory is right, structures and processes are present today in an organism only because they serve useful ends; which comes very near to saying that they are present *in order to* serve those ends. In fact, it is as near as one can get to the in-order-to statement about the heater, without bringing in the divine or animal equivalent of the heating engineer's volition.

And so we arrive at what appears to be a traditional teleological statement, that a structure or process is *in order to* or *for the purpose of* something or other. But of course it is not traditional teleology because it does not depend upon concepts of intention or design. It is merely causality (the effect of natural selection) masquerading as teleology. The terms 'pseudoteleology' and 'teleonomy' have been proposed to distinguish this teleology from traditional teleology; but they do not seem to be widely used.

The Value of Teleology in Biology

Is there any value in teleological explanation in biology, or ought we to be content with causal explanation?

Firstly, even when a causal explanation of some biological feature can be given, it usually contributes significantly to our understanding of that feature if we can give also a teleological explanation. Thus animal migration can often be explained causally in terms of external stimuli or internal endocrine changes, but it is intellectually much more satisfying if we can explain also that it enhances the migrant's food supply or facilitates the survival of its offspring.

Secondly, it is often much easier to find a teleological explanation than a causal one. The biological significance of the mammalian heartbeat has been very clearly understood since Harvey published his famous work in 1628, but the causal mechanisms involved are only now coming to light. And any valid explanation is better than none.

Thirdly, teleological questions both stimulate and guide research. I suspect that more often than not the first question a biologist asks about a newly discovered character is 'What is its function?'. In seeking the answer to this he frequently obtains clues to causal mechanisms.

Conclusions

1. Teleology is valid in biology.
2. Teleological explanation relates the explicandum either to some future biologically valuable consequence or to the whole orderly system of which it forms a part.
3. Teleological relations are just as objectively and empirically discernible as are causal relations.
4. Biological teleology differs from traditional teleology in that it does not invoke the concepts of divine plan or animal intention, but is rather an implication of causality.
5. Acceptance of the theory of natural selection is not a necessary basis of teleology (one can recognize biological significance without invoking it), but it does explain causally the existence of adaptive features.
6. Teleology is valuable in biology in that it gives a broader view of biological features than does causal explanation alone. It also stimulates and facilitates research.

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