CHAPTER 4

BEHAVIOR, PURPOSE AND TELEOLOGY

1. Introduction. Teleological explanations

We have mentioned the paradox of backward causation, which afflicted the explanation of purposeful behavior. This kind of behavior seemed to consist in an inversion of the causal sequence: the future or final result of an action (the end to which it is directed) *precedes* or *anticipates* the action. "A sequence entirely inadmissible in a world of pure mechanism," was how McDougall (1923a: 194) saw it. What was known as the metaphysical solution of the paradox always saw the end or the goal of an action as its 'final cause,' and teleological explanation was considered completely different from causal explanation.[1] Thus an unbridgeable gulf opened up between teleology and science, one that challenged the very plausibility of using teleological language in the scientific study of the behavior of living organisms.

The question of purpose and teleological or, generally speaking, mentalistic language has emerged in different contexts in our investigation into the discovery of the artificial. For those whom McDougall would have classified as supporters of Automaton Theories, the instinctive behavior of man and animals was nothing but chains of reflexes that were always *automatic*, no matter how complicated they might be.

For Loeb, for example, eliminating in this case subjective terms such as 'choice,' 'purpose' and so on meant doing a service on behalf of science. According to Meyer, the replacement of subjective by neurophysiological language was always the ideal at which a purely objective science of behavior should aim. Without supporting vitalism, Jennings had insisted instead on the need to use mentalistic language for the purpose of controlling and predicting the behavior of even the lower animals. He also used it in describing various phenomena in the *inorganic* world in order to show that it could be used objectively.

In Hull's robot approach, the notions of automatism and purpose did not seem incompatible, since machines could simulate at least "rudimentary" forms of anticipatory behavior. It was expected that a "psychic" machine would do better in the future and incorporate principles that explained more complex behavior, such as the principle of anticipatory goal reaction, which for Hull was the basis of purposeful behavior. Rashevsky explicitly legitimized the use of mentalistic and teleological language for the prediction of the behavior of the 'new' machines. Since these machines could change their internal

[1] The peculiarity of the teleological explanation has been debated at great length by philosophers, but it is not our purpose to discuss this point here. Moreover, among the many people who dealt with the issue during the years we are concerned with in the present chapter (the period before cybernetics), we shall refer only to some of those who were sensitive to the possibility of *extending* teleology to the processes of the inorganic world, and especially to machines. For aspects of the teleological explanation that are relevant to our purposes, there are the insightful analyses s by Boden (1972) and Zuriff (1985).

organization in response to stimuli from the environment, they could display a degree of unpredictability. Thus it was impossible to know *a priori* the 'purpose' of their responses and, in the case of more evolved future machines, whether they 'lied.'

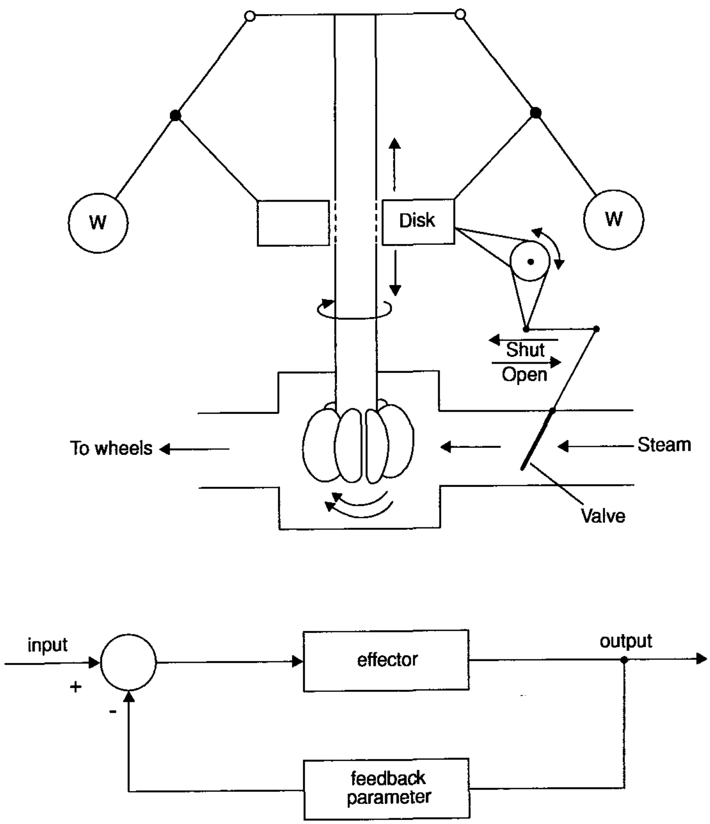
It is usual to date the first modern attempt to reinstate teleology within scientific knowledge, so to speak, to the famous 1943 article by Arturo Rosenblueth, Norbert Wiener, and Julian H. Bigelow, "Behavior, Purpose, and Teleology." The three scientists seemed to be risking their very solid reputations, as Miller, Galanter, and Pribram remarked with some irony, when they claimed that machines with negative feedback display teleological behavior (see Plate 4.1). As the authors themselves remarked, at the time "teleological" was synonymous with "unscientific," and the 1943 article seemed to give the term new respectability in behavioral sciences (Miller et al., 1960: 42).

In their article, Rosenblueth, Wiener and Bigelow proposed a *general method* for studying a system or "behaving object" in its environment and a *classification* of the different kinds of behavior in the environment of such a system or object. Their aim was to give proper weight to the importance of the concept of purpose, which would allow an objective, albeit "restricted," definition of teleology; restricted because freed from the "vague concept of a 'final cause'" (Rosenblueth et al., 1943: 23).

The authors called their method "behavioristic." It centered on an observer who studies the relationships that a system maintains with the environment in which it is located, and its responses or "outputs" as a function of certain stimuli or "inputs." This study is independent of the specific nature and internal structure of the system, which may be studied by another, so-called "functional" method. From the point of view of behavioristic study, the system and its environment are inseparable. Indeed, they constitute a veritable single system. The classification of behavior that followed the statement of the behavioristic method proceeded in dichotomous fashion. Thus, it was possible to distinguish a class of behavior that could be classified as "teleological." This behavior was "purposeful" in the specific sense of being modified and guided by continuous (negative) feedback from the goal state. In other words, teleological behavior is controlled by the error of the reaction, i.e. "by the difference between the state of the behaving object at any time and the final state interpreted as the purpose" (p. 24).

The claim of the three authors was that teleological behavior so defined was observable not only in living organisms but also in *certain* machines. Tropisms were examples of telelogical behavior in the case of simple organisms, while in more complex organisms, activities such as the pursuit of prey were classified as teleological. Servomechanisms are machines that are endowed with negative feedbacks and as such can display teleological behavior, so that they may be considered "intrinsically purposeful" (p. 19). A simple thermostat that keeps room temperature fairly constant is an example, but so is a radar-controlled gun, in which information provided by radar about a moving target, an airplane, say, is constantly fed back to alter the gun's aim. However the behavior of a thermostat and the tropistic behavior of a simple organism are both different than the behavior of the gun-radar-airplane system and the predator-prey system. The latter behavior displays the ability of machine and organism alike to 'extrapolate' or 'predict' a *future* point in a trajectory described by the moving object (the target aircraft and the prey

Plate 4.1



An example of a *negative-feedback* device is the centrifugal governor developed by James Watt (1736-1819), which is placed in a steam engine. Clerk Maxwell gave the mathematical treatment of governors in his famous 1868 essay "On Governors," which Wiener mentioned as the source that suggested the term 'cybernetics' to him (the word 'governor' is meant as the Latin corruption of the Greek word *kubernétes*, i.e. 'steersman')

Watt's governor (above in the figure) is placed in the steam-supply pipe, and monitors the amount of steam flowing to the wheels of the machine. The shaft of the device, guided through gears by the drive shaft, rotates, lifting the two weights (W). These pull up a disk, which, acting through a set of levers, vary the opening of a valve, which shuts as the weights rise and opens as they fall. In this way, the speed of drive shaft is kept fairly constant.

The block diagram (below in the figure) shows the functioning of the device, based on this principle of error correction (the circle indicates that the actual response is compared with the desired response, so giving the correction signal). When the counter-signal acts to augment the final effect instead of reducing it, one speaks of *positive feedback*.

respectively). So according to the authors, teleological (negative-feedback) behavior is subdivided into two classes: "non-extrapolative" or "non-predictive" and "extrapolative" or "predictive."[2]

An earlier article by Ashby, "Adaptiveness and Equilibrium" (Ashby, 1940) revealed an interest in feedback in describing purposeful behavior.[3] Here too the aim was to avoid "all metaphysical complications of 'purpose'" (p. 483). The guiding spirit behind the two articles might seem different. Ashby was not so much interested in reinstating teleological language, albeit in restricted form, as in "substituting," as he put it, the "vague" teleological notion of adaptation with a "quantitative" notion, that of *stable equilibrium*. Although in this case the distinction was probably more verbal than substantial, the formulation of the problem by Rosenblueth, Wiener and Bigelow was more provocative and was destined to give rise to a flood of discussion among philosophers and researchers in various fields, such as biologists, neurologists, psychologists and computer scientists, later on.

Even before the publication of these two articles, there were philosophers and scientists who had pointed out that certain artifacts endowed with what was later to be called negative feedback behaved in a way that an outside observer might interpret in teleological terms, and that this might corroborate the possibility of giving an objective, albeit variously "restricted," definition of teleology. While this claim raised problems of its own, it suggested that there was no need to appeal to the idea of a final cause to avoid the paradox of backward causation, and that in principle there was no contradiction between *mechanical* and *purposeful* processes, between machine and teleology.

In the present chapter, we shall examine these less familiar aspects of the discussion between science and philosophy about teleology in the years before the cybernetic era. In the last two sections of the chapter, we will argue that this discussion was clarified by the ideas of the control system and information transmission that emerged on the threshold of cybernetics. In this regard, we will pay particular attention to the role of Kenneth Craik. Partly because of his explicit references to the robot approach, Craik seems to mark the transition from the mechanistic stance of behavioral sciences in the early twentieth century to the stance that merged in the 1940s with the development of the theory and technology of automatic control.

2. Adaptation as equilibration. Lillie and the "reconciliation" of teleology with science

A useful starting point for our investigation is Ralph S. Lillie's 1915 study of purposeful behavior.[4] His interest in processes of equilibration were in a line of research running from

[2] In describing Rosenblueth, Wiener and Bigelow's classification of behavior we have intentionally mixed description and examples given in their article with those in later writings by Wiener and other cyberneticians. Examples from warfare should come no surprise: as mentioned earlier (see pp. 6-7) cybernetics was given much impetus during World War II.

[3] Ashby did not use the term 'feedback' in this article (though he did soon after) to describe such behavior. Instead he used the term "circuit" in reference to the close relationship between organism and environment, and in this regard he mentioned von Uexküll's "functional circles" (see above, p. 18).

[4] Lillie was a physiologist who studied cell processes, organic growth, and metabolism. For his idea of "inor-

Spencer and Jennings all the way to the aforementioned remarks of Ashby. Lillie wondered how to "reconcile" the teleological description of living organisms, according to which they demonstrate purposeful behavior in adapting to the external environment, with their scientific study, namely study that is limited to describing them as material systems in an environment with which they interact. From the latter viewpoint, the systems have "peculiarities that may not ultimately be accounted for on the basis of [their] physico-chemical constituents alone" (Lillie, 1915: 590).

According to Lillie, the only way to reconcile teleology with the scientific study of organisms is to consider their behavior purposeful solely on the basis of what he called "external marks of purpose": these may give rise to an "objective" use of teleological language. Considered objectively, purposeful behavior is merely one of several regulation processes by which a complex physicochemical system adapts to the environment. It is a behavior that "is not in its general nature something distinctive of living organisms alone" (*ibid.*)

In Chapter 1, we looked in detail at an argument of this kind, the one that led Jennings to conclude that so-called "teleological" (regulatory) principles existed in the *inorganic* world too. Lillie described the living organism as a system that shares with a class of natural inorganic systems the feature of maintaining a certain structural stability despite variation in external conditions. And it is thanks to this feature that these systems tend to re-establish their initial conditions whenever they are disturbed. A flame is an example of this kind of "stationary system," as Lillie called it, which continually exchanges matter and energy with the environment. These systems thus maintain themselves in a state of dynamic equilibrium characterized by a twofold, constructive and dissipative process. Metabolism is simply a particularly complex way of maintaining that equilibrium and a specific feature of living organisms. Like Jennings first and Ashby later, Lillie considered the organism as inseparable from the environment, and the notion of dynamic equilibrium arises from consideration of their reciprocal influences.

In order to provide a "more precise" definition (p. 592) of the teleological notion of adaptation for organisms, all that is needed, in Lillie's opinion, is to translate such a notion into terms of "maintenance of equilibrium," or metabolic equilibrium in the specific case. Actually, Lillie suggested a classification of the organism's equilibration behavior that included a kind of purposive behavior, and somewhat anticipated the classification that Rosenblueth, Wiener and Bigelow proposed in their 1943 article.

In Lillie's account, the metabolic equilibrium that characterizes living organisms is maintained by a broad class of regulatory processes, some "internal," such as those that maintain body temperature (called "homeostatic" after Cannon), and some "external," concerning the organism's interaction with the environment. The latter are subdivided into "static" and "active" processes. The static ones cover such permanent features of organisms as body shape, pigmentation, and so on, in relation to *permanent* features of the environment. It is a stable correspondence between organism and environment that fos-

ganic models of growth," to which we shall refer later on, see Lillie (1922). In an interesting essay on problems in the philosophy of biology at the time, Joseph Needham included Lillie among the "neomechanists" (in part because of his 1915 article), who rejected the non-quantitative notion of teleology (Needham, 1928: 85 and 88).

Springer

http://www.springer.com/978-1-4020-0606-7

The Discovery of the Artificial
Behavior, Mind and Machines Before and Beyond
Cybernetics
Cordeschi, R.
2002, XX, 314 p., Hardcover
ISBN: 978-1-4020-0606-7