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Declaration of the American Society for Cybernetics

Cybernetics is a way of thinking, not a collection of facts. Thinking involves concepts: forming them and relating them to each other. Some of the concepts that characterize cybernetics have been about for a long time, implicitly or explicitly. Self-regulation and control, autonomy and communication, for example, are certainly not new in ordinary language, but they did not figure as central terms in any science.

Self-regulation was ingeniously implemented in water clocks and self-feeding oil lamps several hundred years B.C. In the scientific study of living organisms, however, the concept was not introduced until the 19th century and the work of Claude Bernard. It has a long way to go yet, for in psychology, the dogma of a passive organism that is wholly determined by its environment, or by its genes, is still frequently accepted without question.

It is much the same with the concept of autonomy. Potentates and politicians have been using it ever since the days of Sparta; but the structural and functional balance that creates organismic autonomy has only recently begun to be studied (e.g. Maturana & Varela, 1980). And there is another side to the concept of autonomy: the need to manage with what is available. That this principle governs the construction of human knowledge, and therefore lies at the root of all epistemology, was first suggested at the beginning of the 18th century by Vico and then forcefully argued by Kant (see Chapter II). The implications of that principle are only today being pursued in some of the sciences.

As for communication, its case is perhaps the most extreme. We are told that the serpent communicated with Adam and Eve shortly after they had been created. Moses communicated with God. And ordinary people have been communicating with one another all along. However, a *theory* of communication was born a mere 40 years ago, when cybernetics began (Wiener, 1948; Shannon, 1948). It was, however, still an observers theory and said nothing about the requisite history of social interactions from which alone the communicators meaning could spring. Cybernetics arose when the notions of self-regulation, autonomy, and hierarchies of organization and functioning inside organisms were analyzed theoretically, that is, logically, mathematically, and conceptually. The results of these analyses have turned out to be applicable in more than one branch of science.

Cybernetics, thus, is metadisciplinary, which is different from interdisciplinary, in that it distils and clarifies notions and conceptual patterns that open new pathways of understanding in a great many areas of experience.

The investigation of self-regulation, autonomy, and hierarchical arrangements led to the crystallization of concepts such as circular causality, feedback, equilibrium, adaptation, control, and, most important perhaps, the concepts of function, system, and model. Most of these terms are popular, some have become fashion words, and they crop up in many contexts. But let there be no mistake about it: the mere use of one or two or even all of them must not be taken as evidence of cybernetical thinking. What constitutes cybernetics is the systematic interrelation of the concepts that have been shaped and associated with these terms in an interdisciplinary analysis which, today, is by no means finished.

Whenever something is characterized by the particular interrelation of several elements, it is difficult to describe. Language is necessarily linear. Interrelated complexes are not. Each of the scientists who have initiated, shaped, and nourished this new way of thinking would describe cybernetics differently, and each has defined it on a personal level. Yet they are all profoundly aware that their efforts, their methods, and their goals have led them beyond the bounds of the traditional disciplines in which they started, and that, nevertheless, there is far more overlap in their thinking than individual divergence. It was Norbert Wiener (1948), a mathematician, engineer, and social philosopher, who adopted the word "cybernetics". Ampère, long before, had suggested it for the science of government, because it derives from the Greek word for steersman. Wiener, instead, defined cybernetics as the science of *control and communication in the animal and the machine*. For Warren McCulloch, a neuroanatomist, logician, and philosopher, cybernetics was experimental epistemology concerned with the generation of knowledge through communication within an observer and between observer and environment. Stafford Beer, industrial analyst and management consultant, defined cybernetics as the science of effective organization. The anthropologist Gregory Bateson stressed that whereas science had previously dealt with matter and energy, the new science of cybernetics focuses on form and patterns. For the educational theorist Gordon Pask, cybernetics is the art of manipulating defensible metaphors, showing how they may be constructed and what can be inferred as a result of their construction. And we may add that Jean Piaget, late in his life, came to see cybernetics as the endeavor to model the processes of cognitive adaptation in the human mind.

Two major orientations have lived side by side in cybernetics from the beginning. One is concerned with the conception and design of technological developments based on mechanisms of self-regulation by means of feedback and circular causality. Among its results are industrial robots, automatic pilots, all sorts of other automata, and of course computers. Computers, in turn, have led to the development of functional models of more or less intelligent processes. This has created the field of artificial intelligence, a field that today comprises not only systematic studies in problem solving, theorem proving, number theory, and other areas of logic and mathematics, but also sophisticated models of inferential processes, semantic networks, and skills such as chess playing and the interpretation of natural language.

Other results of this essentially practical orientation have been attained in management theory and political science. In both these disciplines cybernetics has elaborated principles that clarify and systematize the relations between the controller and the controlled, the government and the governed, so that today there is a basis of well-defined theories of regulation and control (Ashby, 1952; Conant, 1981; Powers, 1973).

The other orientation has focused on the general human question concerning knowledge and, placing it within the conceptual framework of self-organization, has produced, on the one hand, a comprehensive biology of cognition in living organisms (Maturana & Varela) and, on the other, a theory of knowledge construction that successfully avoids both the absurdities of solipsism and the fatal contradictions of realism (von Foerster, McCulloch, von Glasersfeld).

Any attempt to know how we come to know is obviously self-referential. In traditional philosophy and logic, crude manifestations of self-reference have always been considered to be an anomaly, a paradox, or simply a breach of good form. Yet, in some areas, processes in which a state reproduces itself have been domesticated and formally encapsulated; and they have proven extremely useful (e.g., eigenvalues in recursive function theory, certain topological models derived from Poincaré, condensation rules in logic, and certain options in programming languages for computers, especially for application to non-numeric computations such as in knowledge engineering and expert systems). The formal management of self-reference was dramatically advanced by Spencer Browns calculus of indications (19••), in which the act of distinguishing is seen as the foundation of all kinds of relationships that can be described, including the relationships of formal logic. Recent studies, building on that foundation and extending into various branches of mathematics, have thrown a new light on the phenomenon of self-reference (Varela, Goguen, Kauffman).

The epistemological implications of self-reference have an even wider range of influence in the cybernetical approach to the philosophy of science. Here there is a direct conflict with a tenet of the traditional scientific dogma, namely the belief that scientific descriptions and explanations should, and indeed can, approximate the structure of an objective reality, a reality supposed to exist as such, irrespective of any observer. Cybernetics, given its fundamental notions of self-regulation, autonomy, and the informationally closed character of cognitive organisms, encourages an alternative view. According to this view, reality is an interactive conception because observer and observed are a mutually dependent couple. Objectivity in the traditional sense, as Heinz von Foerster has remarked, is the cognitive version of the physiological blind spot: we do not see what we do not see. Objectivity is a subject's delusion that observing can be done without him. Invoking objectivity is abrogating responsibility, hence its popularity.

Observer-observed problems have surfaced in the social sciences with the emergence of the notion of understanding. In anthropology, for example, it has been realized that it is a sterile undertaking to analyze the structure of a foreign culture, unless a serious effort is made to understand that culture in terms of the conceptual structures that have created it. Similarly, in the study of foreign or historical literature, the hermeneutic approach has been gaining ground. Here, again, the aim is to reconstruct meaning in terms of the concepts and the conceptual climate at the time and the place of the author. The emerging attitude in these disciplines, though traditionalists may be reluctant to call it scientific, is in accord with cybernetical thinking.

The most powerful and encouraging corroboration of the cybemetician's disengagement from the dogma of objectivity, however, comes from the hardest of the sciences. In physics, the problem of the observer reared its head early in this century. The theories of relativity and quantum mechanics almost immediately raised the question of whether they actually pertained to an objective reality or, rather, to a world determined by observation. For some time the question was not answered definitively. Einstein was hoping that the realist interpretation would eventually lead to a homogeneous view of the universe. Heisenberg and Bohr tended the other way. The most recent in the long series of particle experiments have lessened the chances of realism. Realism in this context was the belief that particles, before anyone observes them, are what they are observed to be. Physics, of course, is not at an end. New models may be conceived, and the notion of an objective, observer-independent reality may once more come to the fore. But at present, the physicist's theories and experiments confirm the cybernetician's view that knowledge must not be taken to be a picture of objective reality but rather as a particular way of organizing experience.

In the few decades since its inception, cybernetics has revolutionized large areas of engineering and technology. Self-regulation has moved from the refrigerator into the cars we drive and the planes we fly in. It has made possible the launching of satellites and "Explorers" of our solar system. It has also saddled us with target-seeking missiles, and it has brought about the computer age with its glories and its dangers.

For many of us, however, this explosion of gadgetry is not the most significant feature. The wheel, the harnessing of electricity, the invention of antiseptics and the printing press have all had somewhat similar effects on the mechanics of living. Cybernetics has a far more fundamental potential. Its concepts of self-regulation, autonomy, and interactive adaptation provide, for the first time in the history of Western civilization, a rigorous theoretical basis for the achievement of dynamic equilibrium between human individuals, groups, and societies. Looking at the world today, it would be difficult not to conclude that a way of thinking which, rather than foster competition and conflict, deliberately aims at adaptation and collaboration may be the only way to maintain human life on this planet.

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