PROLOGUE: A SHORT HISTORY OF CYBERNETICS

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Prologue: A Brief History of Cybernetics

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The field of cybernetics had its origins in a series of conferences sponsored by the Josiah Macy Jr. Foundation from 1946 to 1953. The title of the conferences was "Circular Causal and Feedback Mechanisms in Biological and Social Systems." After Norbert Wiener (1948) published his book, *Cybernetics; or, Control and Communication in the Animal and the Machine*, the Macy conferences were called the conferences on cybernetics (Pias 2003). During World War II scientists had worked on a wide range of problems – shipping supplies safely and efficiently across the North Atlantic, building radar-guided anti-aircraft guns, coding and decoding messages, conducting psychological warfare operations, and maintaining families when the men were away and women were working in factories. Scientists who had worked on projects during the war wanted to discuss their experiences and what they had learned. Wiener had expanded the discussion considerably and included other mathematicians and scientists in the conversation such as the Mexican researcher, physician and physiologist Arturo Rosenblueth. Gregory Bateson and Margaret Mead, two anthropologists, felt that in the course of solving these problems interesting ideas, in particular circular causality, had been developed by engineers and mathematicians. They hoped that the conferences would introduce these ideas to social scientists. Together with the conference chairman, Warren McCulloch, they worked to coach the participants in the meetings on how to talk with each other despite very different disciplinary frames of reference (Kline 2014).

Circular causality has long been a difficult topic for scientists to deal with. One of the informal fallacies is a caution to writers to avoid circular reasoning. Statistical methods, which are used to establish the confidence we have in causal relations, usually assume linear causal relations. However, circular causality is essential in any regulatory process. A thermostat regulating the heat in a room, a driver steering a car on a road, or a manager working to maintain the profitability of a firm are all engaged in a circular process. In each case the regulator affects the system being regulated, observes the results of actions and then formulates another course of action. Note that this sequence of observation and formulation is not only circular, it is more simultaneous than sequential.

Circular causality is essential in biology. Biological organisms survive due to the process of homeostasis. The body consists of many circular processes. We become hungry, so we eat. We become thirsty, so we drink. The body is satisfied for a time, but then the cycle repeats. The iris in the eye regulates the amount of light entering the eye. When the body becomes too hot, it sweats, and evaporation cools it. Biological survival is possible due to a large number of circular causal processes (Cannon 1939). Similarly, the work of McCulloch and Pitts engaged for the first time models of cognition based on circularly interconnected models of logical neurons (McCulloch 1943).

Just as biological systems depend on circular processes, social systems do as well. In commercial transactions and in families communication is fundamental. Each party seeks to influence the decisions and actions of others. The existence of complex organizations such as business firms requires many on-going circular causal processes (Beer 1972). A business firm must continually recruit, hire, and train workers as the company grows and as current workers retire. Finding and working with customers and suppliers entails communication back and forth. Employees continually monitor and modify the internal processes in a firm – advertising, production, purchasing materials and maintaining equipment.

Governments also require many kinds of feedback, a circular process (Deutsch 1963). Ideally governments serve the interests of citizens and citizens control the operations of government through voting, lobbying, oversight by the press, and occasional law suits. The decisions of lower courts can be reviewed by higher courts and even a constitution can be changed by amendment. Given the vital role that circularity plays in biological and social systems, it is surprising that so much of science focuses on linear causal relations. Probably this happens because scientists seek certainty in their knowledge. They want to know what confidence they should have in a particular result of research. But statistical confidence intervals work with measurements (e.g., standard deviation) and linear causal relations. Circular causal relations are more challenging and usually rely on comparing results from a model with time series data.

Looking at circular causal processes has proven to be quite fruitful. For example, Humberto Maturana, Francisco Varela and Ricardo Uribe created the theory of autopoiesis, or self-production, to explain living systems (Maturana & Varela 1980). They noted that a living system has parts which engage in processes that result is new parts engaging in similar processes. There is some variation in the parts and processes produced, which enables evolution.

Because cyberneticians were interested in cognition, a biological process, they were interested in the role of the observer in scientific research. Although scientists sought for many years to exclude the observer in an effort to be unbiased and objective, cyberneticians noted that every statement made is made by an observer to an observer. That is, the observer has purposes within a social context and a history that includes national culture and academic training. Hence, observations independent of the characteristics of the observer are not physically possible. *Second order cybernetics* has been an effort to incorporate this realization into cybernetics. The early work in cybernetics focused on the design of control devices. Second order cybernetics was an effort to apply the same ideas to the observer or designer of control devices, hence to cognition (Foerster 2003).

A further development in cybernetics has been to reconsider social systems as collections of purposeful systems – individuals and organizations. Much of social science research has treated social systems as collections of interacting variables. This is possible only if one makes certain assumptions about the elements of social systems, for example the Efficient Market Hypothesis assumes that economic actors are rational, self-interested profit maximizers who all have the same information and complete information. Recently more attention is being given to the often improbable assumptions that scientists make in constructing their models. One assumption that has been carried over from the natural sciences to the social sciences, is that theories do not alter the system observed. Although we assume that physical objects do not change their behavior when scientific theories change, social systems do change their behavior depending on which theory is guiding actions, for example the theories of Adam Smith, Karl Marx, John Maynard Keynes, or Milton Friedman.

The latest developments in cybernetics have been theories of *reflexivity*. Vladimir Lefebvre (1982) suggests that there are two systems of ethical cognition depending on whether one believes the end justifies the means or the end does not justify the means. George Soros (1987) has pointed out that people in societies, including scientists, not only observe, they also participate. The fact that the elements of social systems are both observing and participating greatly increases uncertainty about future events within a society and explains the fallibility of our predictions. Heinz von Foerster proposed that since our knowledge of the social world is limited by our experiences, we need other people, whose experiences are different from ours, to support or challenge our perceptions and conclusions. Karl Müller (Müller & Riegler 2014) has suggested that meta research involves a kind of reentry or reconsideration of previous findings. Louis Kauffman (this volume) has described science as a search for invariances in our contextual descriptions and the production/observation of objects through these invariances.

The contributions in this book illustrate that cybernetics is an important contribution to contemporary science. Physics and chemistry provide a theory of the material domain by explaining matter and energy processes. Cybernetics offers a theory of less tangible phenomena by explaining processes of communication and control (Umpleby, 2007). The cybernetics domain is different because both observers and theories influence what happens in social systems, and it is through social systems that all living science occurs. The contributions in this book suggest several possible future directions for cybernetics. They describe how science is changing and propose a unified point of view for classical and second order science (Umpleby 2014).

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