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A Short History of Cybernetics in the United States

The Origin of Cybernetics

Cybernetics as a field of scientific activity in the United States began in the years after World War II. Between 1946 and 1953 the *Josiah Macy, Jr. Foundation* sponsored a series of conferences in New York City on the subject of „Circular Causal and Feedback Mechanisms in Biological and Social Systems." The chair of the conferences was Warren McCulloch of MIT. Only the last five conferences were recorded in written proceedings. These have now been republished.[1] After Norbert Wiener published his book *Cybernetics* in 1948,[2] Heinz von Foerster suggested that the name of the conferences should be changed to „Cybernetics: Circular Causal and Feedback Mechanisms in Biological and Social Systems." In this way the meetings became known as the *Macy Conferences on Cybernetics.*

In subsequent years cybernetics influenced many academic fields – computer science, electrical engineering, artificial intelligence, robotics, management, family therapy, political science, sociology, biology, psychology, epistemology, music, etc. Cybernetics has been defined in many ways: as control and communication in animals, machines, and social systems; as a general theory of regulation; as the science or art of effective organization; as the art of constructing defensible metaphors, etc.[3] The term ‚cybernetics' has been associated with many stimulating conferences, yet cybernetics has not thrived as an organized scientific field within American universities. Although a few cybernetics programs were established on U.S. campuses, these programs usually did not survive the retirement or death of their founders. Quite often transdisciplinary fields are perceived as threatening by established disciplines.

Relative to other academic societies the meetings on cybernetics tended to have more than the usual controversy, probably due to the wide variety of disciplines represented by the participants. Indeed Margaret Mead contributed an article,

Cybernetics of Cybernetics, to the proceedings of the first conference of the *American Society for Cybernetics,* in which she suggested that cyberneticians should apply their knowledge of communication to how they communicate with each other.[4]

Interpretations of Cybernetics

Not everyone originally connected with cybernetics continued to use the term. The original group of cyberneticians created approximately four research traditions.

1. The cybernetics of Alan Turing and John von Neumann became computer science, AI, and robotics. Turing[5] formulated the concept of a Universal Turing Machine – a mathematical description of a computational device. He also devised the Turing test – a way of determining whether a computer program displays „artificial intelligence".[6] The related professional societies are the *Association for Computing Machinery* and the *American Association for Artificial Intelligence.*

2. Norbert Wiener's cybernetics became part of electrical engineering. This branch of cybernetics includes control mechanisms, from thermostats to automated assembly lines. *The Institute of Electrical and Electronics Engineers*, including the *Systems, Man, and Cybernetics Society*, is the main professional society. The principal concern is systems engineering.

3. Warren McCulloch's cybernetics became „second order cybernetics". McCulloch chaired the Macy Foundation conferences. He sought to understand the functioning of the nervous system and thereby the operation of the brain and the mind. The *American Society for Cybernetics* has continued this tradition.

4. Gregory Bateson and Margaret Mead pursued research in the social sciences, particularly anthropology, psychology, and family therapy. Work on the cybernetics of social systems is being continued in the *American Society for Cybernetics* and the *Socio-Cybernetics Group* within the *International Sociological Association*.

Other groups can also be identified. For example, a control systems group within psychology was generated by the work of William Powers.[7] Biofeedback or neurofeedback is a subject of investigation by some researchers in medicine and psychology. The *Santa Fe Institute* has developed simulation methods based on the ideas of self-organizing systems and cellular automata.[8] Some members of the *International Society for the Systems Sciences* have an interest in management cybernetics.

This paper recounts about sixty years of the history of cybernetics in the United States, divided into five year intervals. The emphasis will be on the third and fourth groups, McCulloch's cybernetics and social cybernetics.

Early 1940s

In 1943 two landmark papers were published. Warren McCulloch and Walter Pitts wrote, *A Logical Calculus of the Ideas Immanent in Nervous Activity.*[9] This article sought to understand how a network of neurons functions so that we experience what we call „an idea." They presented their explanation in mathematical form.

Arthuro Rosenblueth, Norbert Wiener and Julian Bigelow published *Behavior, Purpose, Teleology.*[10] They observed behavior, which they interpreted as purposeful, and then sought to explain how this phenomenon could happen without teleology, using only Aristotle's efficient cause. Also in the early 1940s Wiener worked on a radar-guided anti-aircraft gun.

Late 1940s

In the late 1940s the early Macy Conferences were held in New York City.[11] They were attended by scientists including Norbert Wiener, Julian Bigelow, John von Neumann, Margaret Mead, Gregory Bateson, Ross Ashby, Grey Walter, and Heinz von Foerster. By 1949 three key books were published: Von Neumann's and Morgenstern's *Theory of Games and Economic Behavior,*[12] Wiener's (1948) *Cybernetics: Or Control and Communication in the Animal and the Machine,*[13] and Shannon's and Weaver's (1949) *The Mathematical Theory of Communication.*[14] These books defined a new science of information and regulation.

Early 1950s

In the early 1950s more Macy conferences took place. This time proceedings were published with Heinz von Foerster as editor. Meanwhile the first commercial computers were manufactured.

Late 1950s

In the 1950s the CIA was concerned about the possibility of brain-washing and mind control. Under the code name MKUltra experiments with LSD and other drugs were conducted at *Harvard University* and elsewhere.[15] Some of the money for this research was channeled through the Macy Foundation. In one incident, a CIA employee was given LSD without his knowledge. Apparently he thought he was

going mad and jumped out a window of a hotel in New York City. Ted Kaczynski, the Unabomber, when he was a student at Harvard, was an experimental subject of these mind control experiments.[16]

Early checkers-playing programs were written and raised the possibility of artificial intelligence.[17] In 1956 at a conference at *Dartmouth University* people interested in studying the brain and people interested in creating computer programs parted ways. Neurophysiologists valued work that illuminated the nature of cognition. Engineers valued work that led to useful machines. Thereafter the people interested in cybernetics and those interested in artificial intelligence had little interaction.

Following a sabbatical year working with Arthuro Rosenblueth and Warren McCulloch, Heinz von Foerster founded the *Biological Computer Laboratory* (BCL) at the *University of Illinois* in 1958. During the 1960s and early 1970s BCL was the leading center for cybernetics research in the U.S. Frequent visitors were Humberto Maturana, Francisco Varela, Gordon Pask, and Lars Loefgren. Graduates included Klaus Krippendorff, Alfred Inselberg, Crayton Walker, Roger Conant, and Stuart Umpleby.

During the same period the *Mental Health Research Institute* (MHRI) at the *University of Michigan* was the leading center for general systems research in the U.S. The founding director of MHRI was James G. Miller. Other systems scientists at MHRI were Kenneth E. Boulding, Anatol Rapoport, Richard L. Meier, and John R. Platt.

Early 1960s

In the early 1960s several conferences on self-organizing systems were held.[18] One of these conferences was held in 1961 at the *University of Illinois*'s Allerton Park.[19] As a result of an invitation made at this conference, Ross Ashby moved from England to Illinois. The work on self-organizing systems was a forerunner to the field of study now called ‚complexity‘ or ‚complex systems‘.

Although the Macy Foundation Conferences ended in 1953, the *American Society for Cybernetics* (ASC) was not founded until 1964. This seems rather late. Actually the ASC was founded not so much to continue the work of the Macy conferences but rather as a result of the Cold War.[20] During the Presidential campaign in 1960, when John F. Kennedy was elected, there was talk about a „missile gap“ between the United States and the Soviet Union. Not long thereafter there began to be talk about a „cybernetics gap.“ Some people in the Soviet Union thought cybernetics would provide the theory they needed to operate their centrally planned economy. Consequently, the Soviet government generously funded cybernetics research. Some

people in the U.S. government then feared that the U.S. might fall behind in a critical area of research, if this country did not also fund cybernetics research.

In Washington, DC, a cybernetics luncheon club was meeting. The participants included Paul Henshaw, Atomic Energy Commission; Carl Hammer, Univac; Jack Ford, CIA; Douglas Knight, IBM; Walter Munster; Bill Moore, lawyer. This group founded the *American Society for Cybernetics* (ASC). The founding ceremony was held at the Cosmos Club in Washington, DC. A grant from the *National Science Foundation* helped the Society to establish the *Journal of Cybernetics.* A conference on the social impact of cybernetics was held at Georgetown University in 1964.[21] The first conference arranged by the ASC was held in 1967 at the *National Bureau of Standards* in Gaithersburg, MD.[22]

Late 1960s

Social movements in the United States – against the Viet Nam war and for civil rights, women's rights, and environmental protection – produced a time of student activism on campuses. In terms of research it was a productive period for the *Biological Computer Laboratory* (BCL) at the *University of Illinois.*[23]

Early 1970s

At a meeting of the *American Society for Cybernetics* in 1974 in Philadelphia, Heinz von Foerster introduced the term „second order cybernetics."[24] The *Mansfield Amendment,* which was an attempt to reduce campus unrest caused by the Viet Nam War, cut off government funds for research that was not related to a military mission, including research at BCL.[25]

There was an argument between the officers of ASC and the publisher of the *Journal of Cybernetics.* The dispute was submitted to arbitration, and the publisher won. Thereafter the journal continued to be published, but without ASC involvement. The journal published articles primarily in engineering. However, the field of cybernetics was increasingly emphasizing biology and the social sciences.

Late 1970s

Heinz von Foerster retired from the *University of Illinois* in 1976 and moved to California. There he communicated with Paul Watzlawick, John Weakland and others

at the *Mental Research Institute* in Palo Alto. During this time second order cybernetics or constructivist epistemology had a significant impact on the field of family therapy.[26]

In the late 1970s no meetings of the *American Society for Cybernetics* were held. The people connected with BCL attended meetings of the *Society for General Systems Research*, which a few years later changed its name to the *International Society for the Systems Sciences.*

For a few years, due to a conflict among the ASC officers in Washington, DC, there was a rival organization, the *American Cybernetics Association* (ACA), based in Philadelphia. The two organizations came back together a few years later through the efforts of Barry Clemson, Doreen Steg, Klaus Krippendorff and others. The reorganized society used the ASC name and the ACA by-laws. But the society remained small, usually having fewer than 400 members.

Stuart Umpleby, who received his PhD from the *University of Illinois* in 1975 and moved to *The George Washington University* in Washington, DC, received a *National Science Foundation* (NSF) grant for an *Electronic Information Exchange for Small Research Communities.* The BCL group moved into cyberspace.[27] This group, discussing General Systems Theory, was one of nine academic groups using the *Electronic Information Exchange System* (EIES) at *New Jersey Institute of Technology.* For three years in the late 1970s cyberneticians and systems scientists across the United States and a few in Europe communicated with each other using email and computer conferencing via dumb terminals and, initially, 300 baud modems. The long distance telephone charges were paid by the NSF grant. When the grant ran out, there was disappointment that universities would not pay the communications charges. Indeed, it took almost fifteen years before costs declined sufficiently to permit regular email communication among academics.

Early 1980s

As a result of being the moderator of the on-line discussion group, Umpleby was elected president of ASC. A planning conference in 1980 charted a new direction for the Society.[28] ASC began organizing conferences again and reestablished connections with its former journal, now called *Cybernetics and Systems.*

A series of meetings with Soviet scientists was started as a way to bring leading American scientists together to review fundamentals, in particular to discuss second order cybernetics.[29] The meetings were funded by the *American Council of Learned Societies* and the *Soviet Academy of Sciences.* These meetings were quite productive for exchanging views; however, a controversy with the Soviet side arose over the

participation of Vladimir Lefebvre, a Soviet émigré. Prior to *glasnost* and *perestroika* Lefebvre's theory[30] of two systems of ethical cognition was not accepted by the Soviet government. However, during the break up of the USSR Lefebvre's work was used by people at the highest levels of government in both the United States and the Soviet Union to prevent miscommunication.[31] Lefebvre's work is being further developed through annual conferences organized by Vladimir Lepsky in the *Institute of Psychology* of the *Russian Academy of Sciences* in Moscow. Lefebvre's theory of reflexive control is being used by psychologists and educators to help with the psychological and cultural difficulties involved in the social, political, and economic transition in Russia.[32]

Late 1980s

Members of the *American Society for Cybernetics* began offering tutorials on first and second order cybernetics prior to systems conferences (see Table 1). They were seeking to make a scientific revolution.[33] At a conference in St. Gallen, Switzerland, in 1987 the members of the *American Society for Cybernetics* decided to focus their attention almost exclusively on advancing second order cybernetics.[34] The focus on second order cybernetics to the exclusion of other interpretations of cybernetics had the effect of reducing the membership of the ASC to about one hundred members. However, there was strong interest in second order cybernetics in Europe.[35]

Table 1. Definitions of First and Second Order Cybernetics

Author	First Order Cybernetics	Second Order Cybernetics
von Foerster	The cybernetics of observed systems	The cybernetics of observing system
Pask	The purpose of a model	The purpose of modeler
Varela	Controlled systems	Autonomous systems
Umpleby	Interaction among the variables in a system	Interaction between observer and observed
Umpleby	Theories of social systems	Theories of the interaction between ideas and society

The second Soviet-American conference was held in Tallinn, Estonia, in 1988. Due to *glasnost* and *perestroika* the original topics (epistemology, methodology, and management) were expanded to include large-scale social experiments.

Early 1990s

In 1990 two symposia on *Theories to Guide the Reform of Socialist Societies* were held in Washington, DC, and Vienna, Austria.[36] These meetings were the beginning of a multi-year effort both to understand the changes occurring in the former Soviet Union from the perspective of social theory and to use knowledge of social systems to guide the transitions.

   The work on second order cybernetics was also changing. The members of the ASC had worked almost twenty years on developing and promoting the point of view known as second order cybernetics or constructivism. Some people wanted to move from a period of revolutionary science to a new period of normal science.[37] One way to understand the change is to say that the period of engineering cybernetics lasted from the mid 1940s to the mid 1970s. The period of biological cybernetics or second order cybernetics lasted from the mid 1970s to the mid 1990s. And the period of social cybernetics began in the mid 1990s (see Table 2).

Late 1990s

Symposia on the transitions in the former Soviet Union continued to be held as part of the *European Meetings on Cybernetics and Systems Research*. These meetings are held every two years in Vienna, Austria. The symposia bring together scientists from East and West.

   In Washington, DC, a series of meetings on the *Year 2000 Computer Problem* were held with the support of *The Washington Post.* These meetings were based on the idea that „y2k" could be regarded as an experiment which would reveal the amount of interconnectedness in our increasingly cybernetic society.[38]

   Niklas Luhmann's writings in sociology introduced ideas such as constructivism and autopoiesis to social scientists in Europe.[39] A *Socio-Cybernetics Working Group* within the *International Sociological Association* was established by Felix Geyer and others.

Early 2000s

In the early years of the 21st century large conferences on informatics and cybernetics were organized by Nagib Callaos and his colleagues in Orlando, FL. One result has been organizing efforts in Latin America stimulated by the conferences in Orlando. Annual conferences on reflexive control began to be held in Moscow

Table 2. Three Versions of Cybernetics

	Engineering Cybernetics	Biological Cybernetics	Social Cybernetics
The view of epistemology	A realist view of epistemology: knowledge is a „picture" of reality	A biological view of epistemology: how the brain functions	A pragmatic view of epistemology: knowledge is constructed to achieve human purposes
A key distinction	Reality vs. Scientific Theories	Realism vs. Constructivism	The biology of cognition vs. the observer as a social participant
The puzzle to be solved	Construct theories which explain observed phenomena	Include the observer within the domain of science	Explain the relationship between the natural and the social sciences
What must be explained	How the world works	How an individual constructs a „reality"	How people create, maintain, and change social systems through language and ideas
A key assumption	Natural processes can be explained by scientific theories	Ideas about knowledge should be rooted in neurophysiology	Ideas are accepted if they serve the observer's purposes as a social participant
An important consequence	Scientific knowledge can be used to modify natural processes to benefit people	If people accept constructivism, they will be more tolerant	By transforming conceptual systems (through persuasion, not coercion), we can change society

and may lead to the founding of a Russian Association in the field of cybernetics and systems.

In the *International Society for the Systems Sciences* there is growing interest in group facilitation and participation methods.[40] An increasing number of books about cybernetics appear, frequently by German authors.[41] A *Heinz von Foerster*

Society was established in Vienna to further develop the ideas explored at the *Biological Computer Laboratory*. A new biography of Norbert Wiener was published which explains the break that occurred between Wiener and McCulloch.[42]

The „global university system" created by the Internet and the Bologna process is not only greatly facilitating communication among scientists around the world but is also leading to a new metaphor for the social implications of cybernetics, an alternative metaphor to the „global brain."[43]

Questions about the History of Cybernetics

Given the promising and exciting beginnings of cybernetics, the outstanding scientists involved, and the subsequent impact of cybernetics on many disciplines, it is curious that the term ‚cybernetics' is not widely known or used today, even though most professional people spend several hours a day in cyberspace. Margaret Mead commented on the development of cybernetics at the first ASC conference in 1968:

> „We were impressed by the potential usefulness of a language sufficiently sophisticated to be used to solve complex human problems, and sufficiently abstract to make it possible to cross disciplinary boundaries. We thought we would go on to real interdisciplinary research, using this language as a medium. Instead, the whole thing fragmented. Norbert Wiener wrote his book *Cybernetics*. It fascinated intellectuals and it looked for a while as if the ideas that he expressed would become a way of thought. But they didn't."[44]

Why did the cybernetics movement break up following the Macy Conferences? Perhaps it never came together. People stayed in their home disciplines. Many very thought-provoking meetings were held under the label of cybernetics, but the educational programs that were established did not survive in discipline-oriented universities. When their founders retired, the programs were closed. One consequence of the lack of educational programs at universities is that key ideas tend to be reinvented. One example is the work on complex systems centered at the *Santa Fe Institute*. These writers rarely refer to the work in cybernetics and systems theory.

What prevented unity? There was never agreement on fundamentals. Eric Dent in his doctoral dissertation at *The George Washington University* provides an explanation of the continuing heterogeneity of the field of cybernetics and systems science.[45] Dent claims that after World War II the systems sciences dramatically expanded the scientific enterprise. Specifically, science expanded along eight dimensions: causality, determinism, relationships, holism, environment, self-organization,

reflexivity, and observation.[46] However, not all of the various systems fields chose to emphasize the same dimensions. Indeed, each field chose a unique combination. This meant that the various systems fields did not agree on what the key issues were. As a result each subfield developed its own language, theories, methods, traditions, and results.

These eight dimensions have both united and divided the systems sciences. The dimensions unite the systems sciences because each of the subfields of systems science uses at least one of the new assumptions, whereas classical science uses none. The dimensions divide the systems sciences because each subfield emphasizes a different dimension or set of dimensions. Hence, issues that are very important in one subfield are less important or do not arise in other subfields. Given different questions, the answers in theories and methods have been different.[47] Perhaps in the 21st century the progress made in developing the field of cybernetics in many disciplines will be successfully integrated.

Notes

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