# How cybernetics connects computing, counterculture, and design

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"Man is always aiming to achieve some goal and he is always looking for new goals."
—Gordon Pask[1]

Beginning in the decade before World War II and accelerating through the war and after, scientists designed increasingly sophisticated mechanical and electrical systems that acted *as if* they had a purpose. This work intersected other work on cognition in animals as well as early work on computing. What emerged was a new way of looking at systems—not just mechanical and electrical systems, but also biological and social systems: a unifying theory of systems and their relation to their environment. This turn toward "whole systems" and "systems thinking" became known as cybernetics. Cybernetics frames the world in terms of systems and their goals.

This approach led to unexpected outcomes.

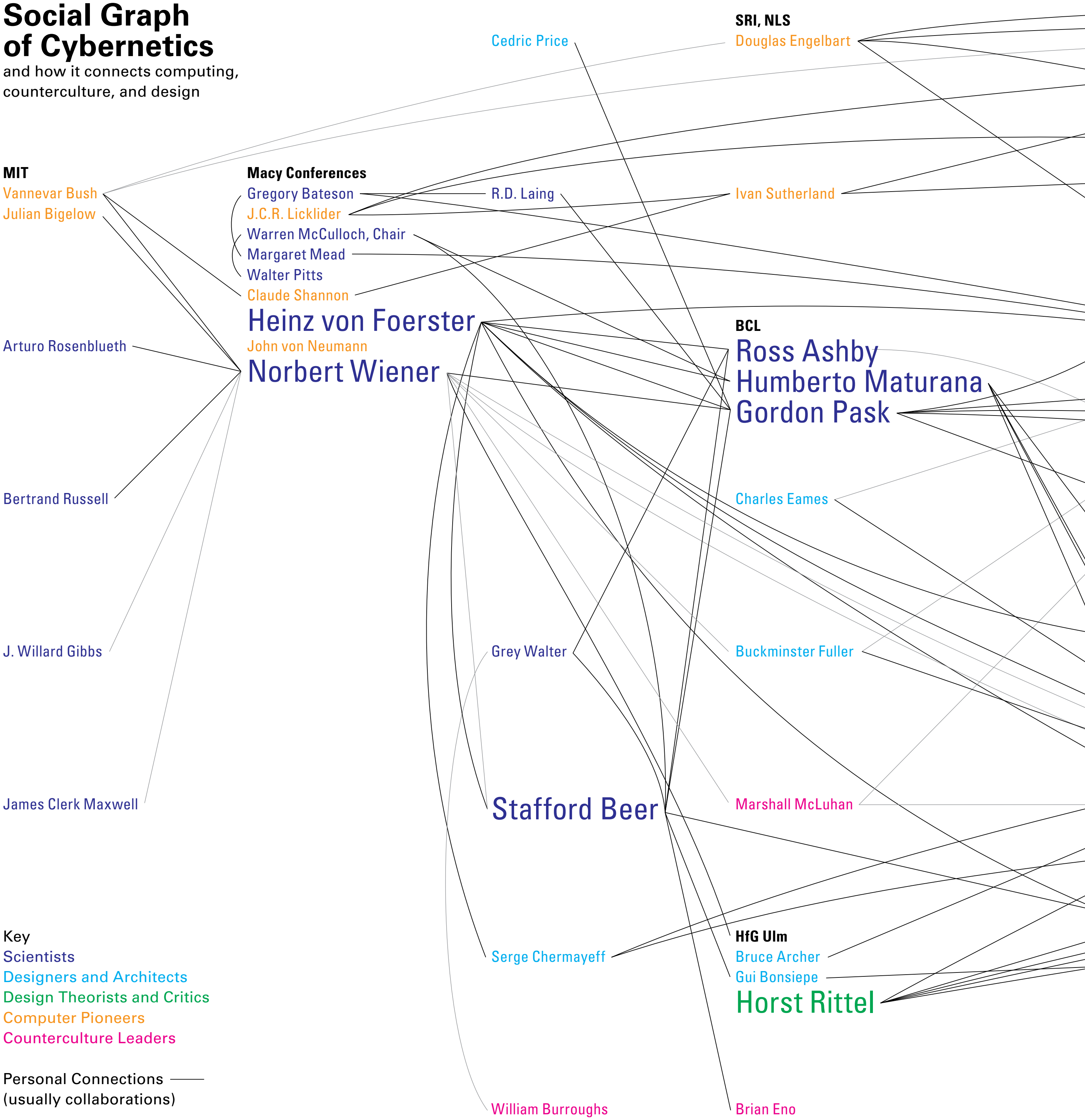
Systems achieve goals through iterative processes, or "feedback" loops. Suddenly, serious scientists were talking seriously about circular causality. (A causes B, and B causes C, *and* C causes A.) Looking more closely, scientists saw the difficulty of separating the observer from the system. Indeed, the system appeared to be a construction of the observer. The role of the observer is to provide a description of the system, which is provided to another observer. The description requires language. And the process of observing, creating language, and sharing descriptions creates a society.[2] Suddenly, serious scientists were talking seriously about subjectivity—about language, conversation, and ethics—and their relation to systems and to design. Serious scientists were collaborating to study collaboration.

This turn away from the mainstream of science became a turn toward interdisciplinarity—and toward counterculture.

Two of these scientists, Heinz von Foerster and Gordon Pask, took an interest in design, even as design was absorbing the lessons of cybernetics. Another member of the group, Gregory Bateson, caught the attention of Stewart Brand, systems thinker, designer, and publisher of the *Whole Earth Catalog*. Bateson introduced Brand to von Foerster.[3] Brand's *Whole Earth Catalog* spawned a do-it-yourself publishing revolution, including von Foerster's 500-page *The Cybernetics of Cybernetics*, futurist Ted Nelson's *Computer Lib / Dream Machines*, and designers Don Koberg and Jim Bagnal's *Universal Traveler: A Soft-Systems Guide to Creativity, Problem Solving and the Process of Reaching Goals*—as well as several other books about design in this genre of visual and topical collage. In addition to being icons of counterculture, these works are also early (printed) examples of hypertext, a term coined by Nelson. In a sense, they anticipate the interconnectedness of the World Wide Web. Nelson's work on hypertext intersects Pask's work on conversation theory, and both lay foundations for the future of human-computer interaction.

# Social Graph of Cybernetics

and how it connects computing, counterculture, and design

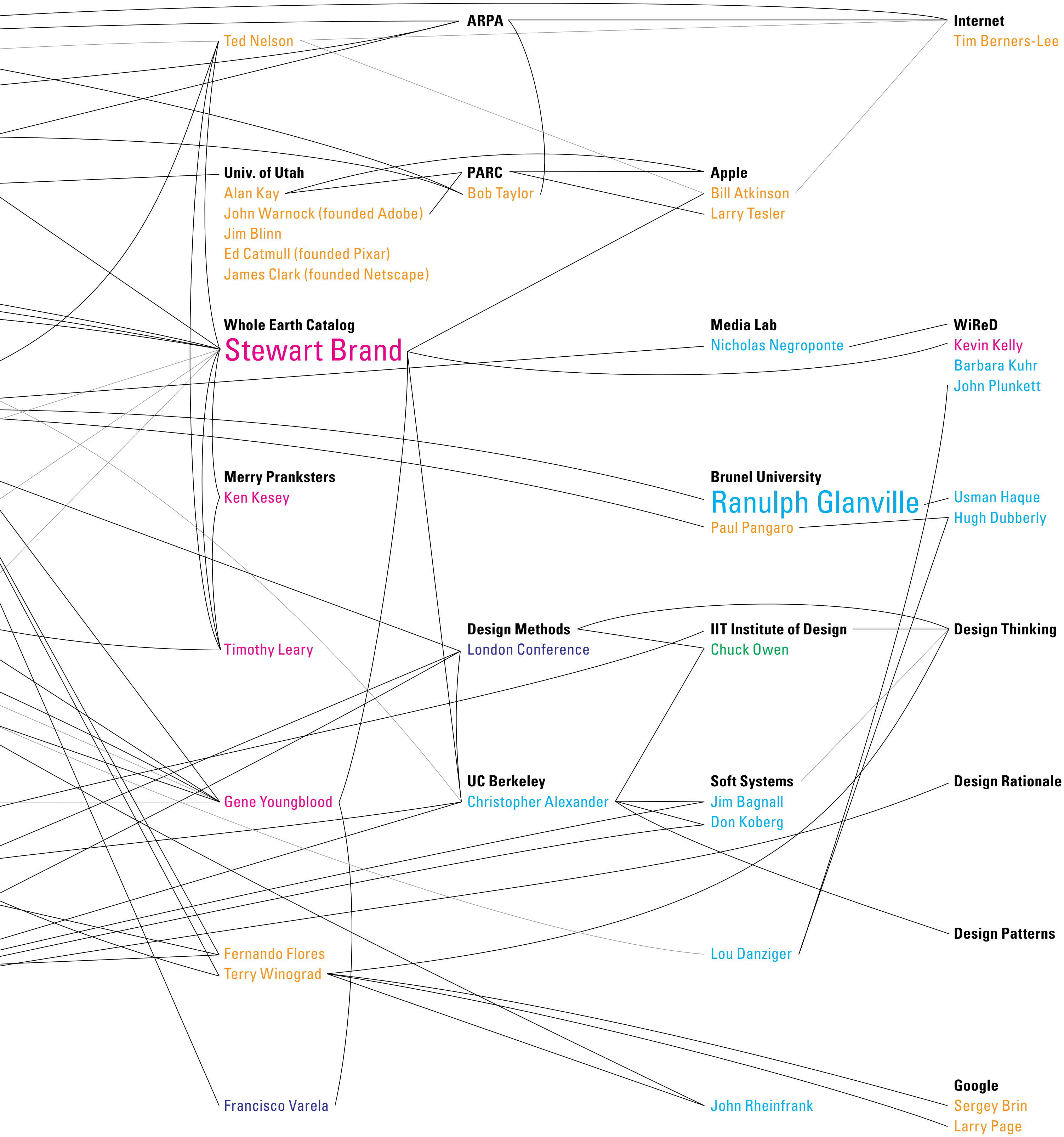



Key
Scientists
Designers and Architects
Design Theorists and Critics
Computer Pioneers
Counterculture Leaders

Personal Connections
(usually collaborations)

Influences
(usually publications)

Interactive version at
http://cybergraph.dubberly.com/


ARPA
Internet
Tim Berners-Lee
Ted Nelson
Univ. of Utah
Alan Kay
John Warnock (founded Adobe)
Jim Blinn
Ed Catmull (founded Pixar)
James Clark (founded Netscape)
PARC
Bob Taylor
Apple
Bill Atkinson
Larry Tesler
Whole Earth Catalog
Stewart Brand
Media Lab
Nicholas Negroponte
WiReD
Kevin Kelly
Barbara Kuhr
John Plunkett
Merry Pranksters
Ken Kesey
Brunel University
Ranulph Glanville
Paul Pangaro
Usman Haque
Hugh Dubberly
Design Methods
London Conference
IIT Institute of Design
Chuck Owen
Design Thinking
Timothy Leary
UC Berkeley
Christopher Alexander
Soft Systems
Jim Bagnall
Don Koberg
Design Rationale
Gene Youngblood
Design Patterns
Lou Danziger
Fernando Flores
Terry Winograd
Google
Sergey Brin
Larry Page
Francisco Varela
John Rheinfrank

Cybernetics is "deeply inter-twingled" (to borrow Nelson's magical phrase) with the early development of personal computers, the 1960's counterculture, and the rise of the design methods movement, which has enjoyed a recent rebranding as "design thinking."

A trending topic in the 1960s, cybernetics peaked about 1970 and crashed—its ideas absorbed into many fields, the origins of those ideas largely forgotten or ignored. Today, cybernetics is at once everywhere and nowhere—a science with no home of its own—one effect of a successful multidisciplinary approach.

Nevertheless, other effects of cybernetics live on—perhaps most visibly in continuing discourse about the nature of knowledge and cognition; about the representation and embodiment of knowledge and cognition in computers; and about how we interact with computers and how we design for interaction. In part, whatever optimism we have for the future of computing—and whatever utopian visions we may still hold for organizing all the world's information and making it universally accessible[4]—have roots in cybernetics. A historical review may help us understand better where we are, how we got here, and where we might go.

**Cybernetics**

Physicists tend to see the world in terms of matter and energy. In contrast, the cybernetics community began by viewing the world in a new way—through the lens of information, communications channels, and their organization. In this way, cybernetics came into existence at the dawn of the information age, in pre-digital communications and media, by bridging the way humans interact with machines, systems, and each other. Cybernetics focuses on the use of feedback to correct errors and attain goals. It has roots in neurobiology and found practical application during World War II in the development of automatic controls for piloting ships, airplanes, and artillery shells.

Historian Fred Turner points out that cybernetics did not arise "out of thin air."[5] It began as a multidisciplinary activity. The 1943 founding paper, "Behavior, Purpose, and Teleology," was co-written by an engineer, Julian Bigelow; a physiologist, Arturo Rosenblueth; and a mathematician, Norbert Wiener; and was published in *Philosophy of Science*.

After World War II, the United States enjoyed a technology-induced euphoria where anything seemed possible, including putting a man on the moon, creating artificial intelligence, and ending poverty. The Allied Powers had met the challenge of fascism and prevailed—through, it seemed, superior science, technology, and planning, (for example, radar, code breaking, and the atomic bomb) and also through "systems thinking," as exemplified by operations research and cybernetics.

From 1946 to 1953, the Josiah Macy Jr. Foundation organized a series of ten conferences "on the workings of the human mind," originally titled "Feedback Mechanisms and Circular Causal Systems in Biological and Social Systems" and later titled "Cybernetics." The conferences brought together participants from many fields: "physicists, mathematicians, electrical engineers, physiologists, neurologists, experimental psychologists, psychiatrists, sociologists, and cultural anthropologists."[6] More than twenty-five people participated, including Gregory Bateson, J.C.R. Licklider, Warren McCulloch, Margaret Mead, Claude Shannon, Heinz von Foerster, John von Neumann, and Norbert Wiener.

In 1948, partly as a result of the early Macy Conferences, Wiener published *Cybernetics: or Control and Communication in the Animal and the Machine*. Wiener had been a child prodigy, graduating from high school at age eleven, graduating from college at age fourteen; and earning an MA and then a PhD in mathematical logic from Harvard at age nineteen. As Wiener later noted, his book was "more or less technical."[7] Despite that, *Cybernetics* caught the attention of the general public, making Wiener famous and resulting in two more popular books about the subject as well as a two-volume autobiography.

Wiener used "cybernetics" to describe a new science that "combines under one heading the study of what in a human context is sometimes loosely described as thinking and in engineering is known as control and communication. In other words, cybernetics attempts to find the common elements in the functioning of automatic machines and of the human nervous system, and to develop a theory which will cover the entire field…." Wiener noted that as "there was no existing word for this complex of ideas…. I felt constrained to invent one. Hence, 'cybernetics,' which I derived from the Greek word *kubernetes*, or 'steersman,' the same Greek word from which we get our word 'governor.'"[8]

A steersman reacts to wind, tide, and other disturbances, correcting these "errors" to keep his ship on course. Mechanical and electrical governors do much the same thing. In fact, governors are so successful, they have become ubiquitous—the thermostat's bimetallic coil contracts and expands to switch on and off a furnace, maintaining temperature in a room; the toilet's float-valve maintains the water level in a cistern; the automobile's cruise-control system maintains a nearly constant speed up hill and down. These mechanical and electrical governors are similar to their political counterparts—governors who keep the ship-of-state on course, steering as Odysseus did between Scylla and Charybdis, a rock and a hard place.

Wiener focused on the relationship between message and response as the key element, whether in humans or machines:

"When I communicate with another person, I impart a message to him, and when he communicates back with me he returns a related message which contains information primarily accessible to him and not to me.... When I give an order to a machine, the situation is not essentially different from that which arises when I give an order to a person. In other words, as far as my consciousness goes I am aware of the order that has gone out and of the signal of compliance that has come back. To me personally, the fact that the signal in its intermediate stages has gone through a machine rather than through a person is irrelevant and does not in any case greatly change my relation to the signal. Thus the theory of control in engineering, whether human or animal or mechanical, is a chapter in the theory of messages."[9]

Also in 1948, Claude Shannon published a related work, "A Mathematical Theory of Communication." Shannon's theory of communication gives us our modern notions of "information" and "noise."[10] His concept of a message as information is similar to Wiener's concept of message.

In 1945, Shannon's former teacher Vannevar Bush (who had become President Roosevelt's National Science Advisor) published "As We May Think," a seminal article in the history of human-computer interaction. Bush's article is famous for describing the "Memex," a machine for "building trails" through information, which foreshadowed hypertext and the World Wide Web. However, Bush wrote the article because of his concern that through the growing specialization of knowledge and of work, the "investigator is staggered by the findings and conclusions of thousands of other workers—conclusions which he cannot find time to grasp, much less to remember." Adding, the danger is that "... truly significant attainments become lost in the mass of the inconsequential."[11]

While Bush's Memex conceptualized ways of exploring interrelated data through machine means, the problem of communication and understanding among researchers across intellectual fields remained. The Macy Conference participants shared Bush's concern; they also believed as von Foerster relates, "that one can and must attempt communication across the boundaries, and often chasms, which separate the various sciences." Thus, they were drawn together by "more than the mere belief in the worthwhileness of interdisciplinary discussion." If shared conceptual models applicable to solving problems in many sciences could be found, then "by agreeing on the usefulness of these models, we get glimpses of a new *lingua franca* of science...."[12]

In such a universalizing theory, shared conceptual models would force a reconsideration of disciplinary perspectives, as Gordon Pask argued, when cybernetics, "considers economy not as an economist, biology not as a biologist, engines not as an engineer. In each case its theme remains the same, namely, how systems regulate themselves, reproduce themselves, evolve and learn." Taking an interdisciplinary view, Pask argues that cybernetics' "high spot is the question of how they [systems] organise themselves."[13]

Turner concludes that the effect of such interdisciplinary discussions and their development of shared cybernetic models "sent individual participants back to their home disciplines with a deep systems orientation toward their work and a habit of deploying information and systems metaphors. In this way, the Macy meetings helped transform cybernetics into one of the dominant intellectual paradigms of the postwar era."[14]

As discussions matured, the goals of the cybernetics community expanded. By 1968, Margaret Mead was contemplating the application of cybernetics to social problems:

"As the world scene broadens, there is continuing possibility of using cybernetics as a form of communication in a world of increasing scientific specialization ... we ought to look very seriously at the current state of American society within which we hope to be able to develop these very sophisticated ways of handling systems that are, indeed, in dire need of attention. Problems of metropolitan areas, ... The interrelations between different levels of government, the redistribution of income, ... the linkages necessary among parts of large industrial complexes...."[15]

At heart, though, there may have been the promise of an even grander purpose. Gregory Bateson, Mead's first husband, reported that what excited him about the early discussions of cybernetics was that, "It was a solution to the problem of purpose. From Aristotle on, the final cause has always been the mystery.... We didn't realize then (at least I didn't realize it, though [Macy Conference chair] McCulloch might have) that the whole of logic would have to be reconstructed for recursiveness."[16]

## Second-Order Cybernetics

Heinz von Foerster edited the official record of the Macy Conferences on cybernetics. In the introduction, he playfully noted, "... the unifying effects of certain key problems with which all members [of the conferences] are concerned: the problems of communication and of self-integrating mechanisms. Revolving around these concepts *was communication about communication*." [Italics added.][17]

In an early draft, von Foerster also stated that, with the new "conceptual models" of cybernetics, "entities of a higher order of complexity can be penetrated. Processes like stabilization, adaptation, perception, recall and recognition, prediction, information, learning—to give only a short list—can be successfully studied."[18] Already, in 1952, von Foerster was laying the groundwork for a "second-order" cybernetics—meta-cybernetics, self-cybernetics, or the cybernetics of cybernetics.

The idea of applying cybernetics to itself first appears in print in a story Margaret Mead told about attending the 1955 meeting of the Society for General Systems Theory. "I suggested that, instead of founding just another society, they give a little thought to how they could use their theory to predict the kind and size of society they wanted, what its laws of growth and articulation with other parts of the scientific community should be." In 1968, she repeated her suggestion, this time to the American Society for Cybernetics, "Why can't we look at this society systematically as a system...?"[19]

In a 1972 interview with Stewart Brand, Mead added, "I went up at the end of [the GST meeting] and talked to [Ross] Ashby, and he said, 'You mean we should apply our principles to ourselves?'" In the same interview, Bateson explained, "Computer science is input-output. You've got a box ... the science is the science of these boxes. Now, the essence of Wiener's cybernetics was that the science is the science of the whole circuit ... essentially your ecosystem, your organism-plus-environment, is to be considered as a single circuit ... and you are *part of* the bigger circuit." Brand sums it up—the engineer is outside the system, and Wiener is inside the system. In other words, Bateson's engineer imagines the observer can stand *apart* from the system, while cybernetics had begun to see the observer as *part of* the system.[20]

Von Foerster later encapsulated the shift in this way: first-order cybernetics is *"the science of observed systems,"* while second-order cybernetics is "the science of observing systems."[21] In 1975, Brand's Point Foundation used proceeds from the *Whole Earth Catalog* to fund publication of von Foerster's *The Cybernetics of Cybernetics*.[22]

In characterizing this new, "second-order" cybernetics, von Foerster forefronts the dynamism of observation, which calls into question the traditional model of science as "objective." Humberto Maturana, the Chilean biologist whose early career deeply influenced both biology and cybernetics and whose later career is now influencing our understanding of human social systems, says, "Anything said is said by an observer."[23] Maturana's starting point is deceptively obvious: Anything that is said must come from a person saying it. This means that what the person says can only come from the person's point-of-view, namely, an inherently subjective position from which she formulates and communicates what she "sees."

Maturana's statement embodies the stance of second-order cybernetics, namely, that all experience is subject to the particularities of a person. The statement grounds a logical argument leading inevitably to conclude that there is only subjectivity, and that "objectivity" is itself a construction.

His emphasis on what the observer says—on the role of language—is an enduring theme of second-order cybernetics. In his essay "Metadesign," Maturana says, "We human beings ... exist as such in language.... That is, we exist in the flow of living together in the recursive coordinations of behavior that language is.... I call the consensual braiding of language and emotions, *conversation*."[24]

Maturana's interest in humans "living in conversation" is not unique in the cybernetics community. For instance, Gordon Pask developed his "Theory of Conversations" to consider how humans and machines learn. Conversation is clearly a circular process with feedback, correction, and evolution; conversations can also be about conversation—a second-order framing. Bernard Scott writes, "second order cybernetics seeks to explain the observer to herself. This is indeed the goal of conversation theory."[25]

Von Foerster, Maturana, and Pask draw a line from subjective observers to ethics. As von Foerster notes, Pask distinguishes two orders: "one in which the observer enters the system by stipulating the system's purpose" and the other, "by stipulating his own purpose." And because he can stipulate his own purpose "he is autonomous ... [responsible for] his own actions."[26]

Maturana echoes the same theme: "if we know that the reality that we live arises through our emotioning, and we know that we know, we shall be able to act according to our awareness of our liking or not liking the reality that we are bringing forth with our living. That is, we shall become responsible [for] what we do."[27]

Maturana extends that idea of agency, placing responsibility for our desires, our emotions, our language, our conversations, and our technology squarely on us. "We human beings can do whatever we imagine.... But we do not have to do all that we imagine, we can choose, and it is there where our behavior as socially conscious human beings matters."[28] We are responsible for the world in which we live. We are responsible for what we design.

**Cybernetics and Computing**

One of the roots of cybernetics was neurobiology, and the Macy Conferences were first organized to explore "the workings of the human mind." According to Scott, Ashby noted in 1961 that it was up to the second generation of cybernetics to answer the question "What is mind?" as the first generation had answered the question, "What is a brain?"[29] The brain deeply interested scientists in the cybernetics community. Four wrote books on the subject: Ross Ashby's *Design for a Brain*, Stafford Beer's *Brain of the Firm*, John von Neumann's *The Computer and the Brain*, and Grey Walter's *The Living Brain*. All four were interested in making machines that acted as brains. These devices "computed"—though not all of them were computers as we commonly imagine computers today. Instead, many of the cybernetic machines pointed to another path in computing not taken, even as cybernetics influenced the mainstream.

Ashby makes a critical distinction between the approaches of traditional Artificial Intelligence (AI) and cybernetics, "To some, the critical test of whether a machine is or is not a 'brain' would be whether it can or cannot 'think.' But to the biologist the brain is not a thinking machine, it is an acting machine; it gets information and then it does something about it."[30] Sociologist Andrew Pickering describes this distinction in terms of two ways of knowing: the dominant "modern" philosophy of knowledge based on representation and a "non-modern" way of knowing based on performance (acting in the world), which is a central aspect of cybernetics.[31]

If cybernetics was born at the Macy Conferences, it was conceived at the Radiation Laboratory at the Massachusetts Institute of Technology (MIT), where Wiener worked. The Rad Lab, as it was called, had been set up by Vannevar Bush. In his early years at MIT, Wiener had collaborated closely with Bush as did Shannon, who did graduate work on the differential analyzer in Bush's lab from 1936 to 1940.

The Macy Conferences included computer pioneers Claude Shannon, J.C.R. Licklider, and John von Neumann, who invented the basic computer architecture still used today and launched the fields of game theory and cellular automata.

Shannon's 1937 master's thesis showed how Boolean logic—the binary positing of all values as either true or false—could be embodied in switches and laid the groundwork for digital computers. Shannon later supervised Ivan Sutherland's 1962 doctoral thesis, which resulted in Sketchpad, an early computer-based system for drawing and one of the first real-time interactive computer systems. Sketchpad influenced Alan Kay who did his PhD work at University of Utah with Sutherland and around 1972 developed the Dynabook concept—a portable computer tablet "for children of all ages." Later, at Stanford's Artificial Intelligence Laboratory, Kay became friends with Stewart Brand and went on to work at digital pioneers Xerox PARC and Apple.

Licklider became a professor at MIT in 1950. He was instrumental in establishing U.S. government funding for research on computing, which ultimately led to the Internet. His 1960 paper, "Man-Computer Symbiosis" imagines interactive computers. "It will involve very close coupling between the human and the electronic members of the partnership. The main aims are 1) to let computers facilitate formulative thinking … and 2) to enable men and computers to cooperate in making decisions and controlling complex situations."[32] PARC founder Bob Taylor noted that Licklider's paper "provided a guide for decades of computer research to follow."[33] In 1968, Licklider published, "The Computer as a Communication Device." Its first sentence sets the tone: "In a few years, men will be able to communicate more effectively through a machine than face to face."[34]

Another link between cybernetics and computing was the Biological Computing Laboratory (BCL) at the University of Illinois, Champaign-Urbana. The BCL stood in contrast to the university's more traditional Digital Computing Laboratory. Von Foerster, a professor of electrical engineering, founded the BCL in 1958; it operated until 1974 drawing many of cybernetics' leading thinkers: Ashby was a professor at the BCL from 1961 to 1972; Pask was a visiting professor in 1960-61; and Maturana visited in 1967-68. The BCL conducted research in "cybernetics, systems theory, bionics, … parallel computing, neurophysiology, bio-logic, artificial intelligence, symbolic computing, … and self-organizing systems."[35]

The idea of biological computing was not merely a metaphor. Beer, Pask, and others attempted to "grow" computers. Their approach had a practical basis. They realized that some problems are too complex to represent; they thought natural systems might be induced to embody that complexity. According to Pickering, "Beer thought that ecosystems are smarter than we are—not in their representational cognitive abilities, which one might think are nonexistent, but in their performative ability to solve problems that exceed our cognitive ones."[36]

In the 1960s, the BCL built several prototypes that "could be described as 'perception machines.'"[37] Prototyping was common in the cybernetics community—something Turner calls "a rhetorical tactic," a method of increasing awareness and spreading influence. Perhaps the first cybernetic prototype was Wiener and Bigelow's anti-aircraft predictor, which "modeled not only the behavior of aircraft but also the probabilistic nature of biological, mechanical, and social systems of all sorts. Ashby's homeostat modeled processes of self-regulation that could be observed in biological and social domains as well."[38] Grey Walter built light-seeking robot "tortoises." Pask built a series of "chemical computers," *Musicolour* (a device that created a light show in conversation with a human musician), *Colloquy of Mobiles* (a light-seeking, interactive installation), and a series of interactive devices for teaching.[39]

Pask spent another year in Illinois—this time at Chicago Circle—where he had an office on the same floor as Ted Nelson, where the two began a dialog.[40] Nelson was working on his 1974 book, *Computer Lib / Dream Machines*, in which he lays out an egalitarian vision of the future of computing built around new forms of reading and writing. Nelson wrote, "Pask is reducing a field to an extremely formal structure of relations." Nelson concludes, "… this exactly complements the notion of hypertext as I have been promulgating it lo these many years."[41]

Pask also collaborated with Nicholas Negroponte on his architecture machine project and contributed an introduction to Negroponte's 1975 book, *The Soft Architecture Machine*. Negroponte's Architecture Machine Group later became the Media Lab—a space for prototyping human-computer interaction. Stewart Brand spent three months in residence and wrote a book about the Lab and its prototypes.

Brand, of course, was not new to computing. In 1968 at the Joint Computer Conference, he offered advice about staging and operated a video camera during Douglas Engelbart's demo of the Online System, which introduced many of the interface constructs that became central to personal computing. In 1972, the same year Brand published his interview with Mead and Bateson, he published "Space Wars" in *Rolling Stone*, predicting the personal computer revolution. In 1985, he co-founded the WELL, an early online community. And in 1995, he published "We Owe It All to the Hippies" in *Time* magazine, crediting the rise of personal computers to the counterculture.

**Cybernetics and Counterculture**

Cybernetics connected with counterculture on several levels. Perhaps the most obvious was an interest in the brain and the mind, which led to experiments in the effects of strobes and bio-feedback. At another level, cybernetics was, as Pickering notes, simply "odd"—with its chemical and biological computers, synthetic brains, and interactive art pieces—developed largely outside traditional academic and corporate sponsorship, on an "amateur" basis in their practitioner's free time. Yet, at a more fundamental level, cybernetics also questioned basic assumptions about how we organize the world. As Pickering notes, cybernetics challenged conventional dualism with experiments that "threaten the modern boundary between mind and matter, creating a breach in which engineering, say, can spill over into psychology, and vice versa."[42] Pickering further argues that cybernetics presents an alternative to the dominant reductive and "enframing" culture, an alternative that is holistic and "revealing" in its stance—a stance that is "open to possibility."

Turner notes, "Brand came to appreciate cybernetics as an intellectual framework and as a social practice; he associated both with alternative forms of communal organization."[43] Brand traveled between—and connected—several communities: cybernetics (Bateson, Mead, and von Foerster), computing (Engelbart, Kay, Nelson, and Negroponte), and, of course, counterculture (Ken Kesey, the Merry Pranksters, and other communards).

John Markoff has chronicled "how the sixties counter-culture shaped the personal computer industry"—focusing on use of LSD in Silicon Valley, where he describes Brand and Engelbart experimenting with it.[44] Ted Nelson reports that acid guru Timothy Leary introduced him to Heinz von Foerster.[45] Pask also appears to have had a serious amphetamine habit. And von Foerster was a nudist (one reason he and his wife lived in the woods near Pescadero).

Brand's introduction to bohemian culture began earlier, while he was in the Army working as a "military photographer." On his time-off, he got to know the New York art scene, and he became involved with USCO (an artists collaborative, where he also worked as a photographer). Brand notes, "The artists I worked with in New York City in 1961-64 were reading Wiener closely."[46]

Cybernetics became popular just as computers were beginning to be used to make images. Two exhibits featured related work. First *Cybernetic Serendipity: The Computer and the Arts* at the ICA in London in 1968[47] included Pask's *Colloquy of Mobiles* as well as Beer's stochastic analog machine (SAM), and a few months later *The Machine as Seen at the End of the Mechanical Age* at MoMA in New York featured works from Experiments in Art and Technology (E.A.T.), including a piece by Jeff Raskin—later a founding member of Apple's Macintosh computer team.

Also in 1968, Stewart Brand published his first *Whole Earth Catalog*—a bible for the counterculture—a collection of reviews and recommendations, providing "access to tools," promising "intimate, personal power … power of the individual to conduct his own education, find his own inspiration, shape his own environment, and share his adventure with whoever is interested."[48] Decades later, Steve Jobs famously summed up the *Whole Earth Catalog* as, "… one of the bibles of my generation … it was all made with typewriters, scissors, and Polaroid cameras. It was sort of like Google in paperback form, 35 years before Google came along: it was idealistic, and overflowing with neat tools and great notions."[49] Like the search engine giant, the *Whole Earth Catalog* acted as a kind of text-based browser or window onto an aggregated world of products, books, devices, and ideas that were not for sale through the catalog directly, but would in effect create a community or a network of subscribers—likeminded members of the counterculture.[50]

**Cybernetics and Design**

In addition to being a utopian counterculture toolkit and a self-published manifesto for a do-it-yourself lifestyle, the *Whole Earth Catalog* is also an introduction to systems thinking and design.

The catalog's first section "Understanding Whole Systems" juxtaposes Buckminster Fuller and von Foerster's review of mathematician Spencer Brown's *Laws of Form*—followed quickly by biologist D'Arcy Thompson's *On Growth and Form* side-by-side with architect Christopher Alexander's *Notes on the Synthesis of Form*, with a sidebar on von Foerster's *Purposive Systems* thrown in. And then, cheek-by-jowl, are reviews of artificial intelligence pioneer Herbert Simon's *Sciences of the Artificial* and Ludwig von Bertalanffy's *General Systems Yearbook*. On the next the page is a review of Wiener's, *The Human Use of Human Beings*. And that's just in the first few pages.

A bibliographic tour-de-force, the *Whole Earth Catalog* also reviews other classics of design and cybernetics, including works by John Chris Jones, Victor Papanek, Ross Ashby, Warren McCulloch, Nicholas Negroponte, Lawrence Halprin, Gyorgy Polya, George Miller, and many more. Today, it would still be a good reading list for a graduate seminar on both design theory and systems theory.

How did this happen?

Brand says, "As an undergraduate I saw a talk by Charles Eames that got me." Brand had studied magazine design at Stanford in 1959 and graphic design at San Francisco Art Institute in 1960.[51] Turner argues that Buckminster Fuller's notion of a "comprehensive designer" captivated Brand. For Fuller the comprehensive designer was "an emerging synthesis of artist, inventor, mechanic, objective economist and evolutionary strategist."[52] By this definition, Brand's life's work may be about as good an example of comprehensive design as one can find.

The idea of multidisciplinary design was in the air—at the Eames Office (1941), George Nelson Associates (1947), Total Design (1963), Unimark (1965), Pentagram (1972), and with other practitioners. At the Ulm School of Design (HfG) in postwar Germany, where Wiener lectured in 1955, they called this holistic or universal approach "environmental design." Schools in the United States imported the idea and nomenclature, most notably University of California, Berkeley, which transformed its Beaux-Arts School of Architecture into a modernist School of Environmental Design. In 1963, as part of the transformation, Dean William Wurster hired two of the founders of the design methods movement, Horst Rittel and Christopher Alexander.

Rittel had taught classes in operations research and cybernetics at Ulm. His first published work was a series of lectures titled "Kommunikationstheorie in der Soziologie (Kybernetik)" ["Communication Theory in Sociology (Cybernetics)"] in 1958. At Berkeley, Rittel's design methods courses explicitly included concepts from cybernetics. His writings link cybernetics and design, and he describes design as a cybernetic process. What's more, Rittel saw this process as an argumentative conversation, and his work on scaffolding this conversation launched a field of on-going research known as design rationale (processes for making design decisions and software systems to support these processes and document them). Rittel's "design methods of the second generation" echoes second-order cybernetics.[53] Beer's ideas about exceedingly complex systems, their continuously shifting nature, and their ultimate unknowability are remarkably similar to Rittel's ideas about "wicked problems," or those that resist resolution because of their complexity and because stakeholders do not share a common frame of reference.

In 1964, Christopher Alexander published his Harvard PhD dissertation in architecture as *Notes on the Synthesis of Form*. According to Pickering, Alexander made Ashby's *Design for a Brain* (which he repeatedly references) "the basis for" his dissertation[54] "The key concept he takes there from Ashby is precisely the notion of adaptation, and his argument is that unselfconscious buildings are well adapted buildings in several senses: in the relation of their internal parts to one another, to their material environment, and to the social being of their inhabitants … in the field of self-conscious design, attempts to fix misfits ramify endlessly."[55]

In turn, Alexander's work was the basis for Charles Owen's famous "structured planning" courses at Illinois Institute of Technology's (IIT) Institute of Design (ID), which for more than thirty years formed the backbone of ID's uniquely systematic approach to design. Owen reports that he "obtained Alexander's computer programs on punched cards from MIT. After a month of work, we got the programs running on IIT Research Institute's mainframe computer." Owen also attended American Society for Cybernetics meetings.[56] Conversely, Pask and von Foerster attended meetings of the design community.

Von Foerster gave several presentations to design groups, including the Industrial Design Education Association (IDEA) in 1962 and the International Design Conference at Aspen, also in 1962, as well as an address at North Carolina State University, titled "Cybernetics of Design" in 1963. Design critic Ralph Caplan, who also spoke at the IDEA conference, reports, "Far and away the best thing to remember about the conference was von Foerster's brilliant speech, which I loved but probably didn't understand. As for what he was doing at an IDEA meeting, that was not such an oddity. Von Foerster knew plenty about design and everything else." As Caplan notes, Serge Chermayeff—who had been Director of the Institute of Design, taught architecture at Harvard, and collaborated with Alexander—also spoke at the same IDEA conference, and he and von Foerster became "close friends over the years."[57]

### Design as Cybernetics

Ashby and, in turn, Alexander framed design in terms of adaptation, fit, and evolution—that is, as a process of feedback. However, design is not just steering towards a goal (as in first-order cybernetics); design is also a process of discovering goals, a process of learning what matters (as in second-order cybernetics). Pickering contrasts design as problem solving with Ashby's evolutionary and performative approach: "I have always thought of design along the lines of rational planning—the formulation of a goal and then some sort of intellectual calculation of how to achieve it. Cybernetics, in contrast, points us to a notion of design in the thick of things, plunged into a lively world that we cannot control and that will always surprise us … cybernetics serves both to foreground these exigencies (rather than treating them as unfortunate side effects) and to make a virtue of them, to enjoy them!"[58]

In 1962, both Alexander and Pask attended the first design methods conference at the Imperial College in London. Pask also had a visiting position at the Architecture Association in London, where he collaborated with architect Cedric Price on the Fun Palace, an unbuilt but highly influential design for a flexible space—a megastructure he and theater director Joan Littlewood created. In 1969, Pask published "The Architectural Relevance of Cybernetics," explicitly framing design as cybernetics. He anticipates Donald Schön's notion of design as conversation (described in his 1983 book *The Reflective Practitioner*) and goes further than Rittel and others who described design as a cybernetic process.

With its systems-based approach, cybernetics integrated context and relationships, pushing design beyond its object-based approach. The original cybernetic frame of systems and goals and then the second-order cybernetic frame of subjectivity and conversation give rise to a view of design as concerned with much more than the form of objects. Pask noted, "a building cannot be viewed simply in isolation. It is only meaningful as a human environment. It perpetually interacts with its inhabitants, on the one hand serving them and on the other hand controlling their behavior. In other words structures make sense as parts of larger systems that include human components and the architect is primarily concerned with these larger systems; *they* (not just the bricks and mortar part) are what the architect designs."[59] What Pask said about architecture also applies to design for human-computer interaction. A software program interacts with its "users," serving them and yet also constraining their behavior. Software, too, only makes sense when framed as part of larger systems that include humans. These larger systems are what interaction designers design.

While Turner connected the early development of cybernetics to the development of personal computers and the Internet, he largely ignored what cybernetics meant (and continues to mean) for the design of software. In many ways, the story of cybernetics is the pre-history or back-story of interaction design (and thus its successors like service design and experience design). Wiener's notion of feedback is the very foundation of interaction design and thus is the foundation of any framing of design as engaging people rather than as simply giving form to objects. Bush, Engelbart, Sutherland, Licklider, Kay, and Nelson contributed articles, books, and prototypes, which set the agenda for interaction design and which remain required reading (and viewing) for students and practitioners. One could add Ashby, Beer, Maturana, Pask, and von Foerster to this list as well.

As Pask has noted, "architects are first and foremost systems designers," but they lack "an underpinning and unifying theory…. Cybernetics is a discipline which fills the bill."[60] Ranulph Glanville, a student of Pask, argued cybernetics as both theory and praxis, "We can consider design as a practical expression of cybernetics, cybernetics as a theoretical study sustaining design."[61] And Glanville's student Usman Haque adds a coda and a contemporary interpretation: "Architectural systems constructed with Paskian strategies allow us to challenge the traditional architectural model of production and consumption that places firm distinctions between designer, builder, client, owner and mere occupant…. It is about designing tools that people themselves may use to construct—in the widest sense of the word—their environments and as a result build their own sense of agency."[62]

**A Language for the Future**

With their "monster" prototypes and their Frankenstein publications, many of the cybernetics folks were more than scientists. They were designers and hackers. Do-it-yourself pranksters. Drug-taking dreamers. Hypertext hipsters—moving us from Memex to Mosaic. They hastened desktop publishing. They laid the foundation for human-computer interaction, and they paved the way for interaction design.

As they turned their focus to second-order cybernetics and conversation, they created existence proofs for "comprehensive design"—a still emerging approach to design concerned with interaction between humans. By doing so, they gave us hope for the future—hope that we might work together to save the whole earth.

In the past twenty years, design has begun to catch up with cybernetics. Design practice has become enmeshed in systems and ecologies. Collaboration and transdisciplinarity have become key themes. What's more, we now recognize that the major issues the world faces—the issues that really matter—are all systems issues. They are wicked problems, which means they are essentially political in nature and cannot be "solved" by experts. We are, in Rittel's phrase, enmeshed in a "symmetry of ignorance."[63] The only way forward is through conversation. These facts make cybernetics newly relevant, because it offers tools and models, as it did at the Macy Conferences—for grappling with systems issues and the unknowable "messes" that confront us—a *lingua franca* of design. As Pask noted: "Human interaction is a major source of difficulties which can only be overcome by cybernetic thinking."[64]

**Endnotes**


1
Gordon Pask, "A Comment, a Case History, and a Plan," in *Cybernetics, Art and Ideas*, ed. Jasia Reichardt (Greenwich, CT: New York Graphics Society, 1971), 76.

2
Heinz von Foerster, "Cybernetics of Cybernetics," in *Understanding Understanding: Essays on Cybernetics and Cognition*, (New York: Springer, 2003), 283-287.

3
Stewart Brand, correspondence with author Hugh Dubberly, January 31, 2015.

Historian Bruce Clarke points out that von Foerster sent a copy of the *Whole University Catalogue* (1969) to Brand, initiating a correspondence leading to Brand asking von Foerster to contribute to the *Whole Earth Catalogue*. (Bruce Clarke, correspondence with author Paul Pangaro, August 5, 2015.)

Clarke also points out that the *Whole University Catalogue* (1969), *Ecological Source Book* (1970), and *Metagames* (1972) were precursors to *Cybernetics of Cybernetics* (1974). Von Foerster co-created all four books with students in a series of courses at University of Illinois on "Heuristics." In a sense, von Foerster began to teach design, not just publication design but design grappling with wicked problems, what today might be seen as an early form of design for social innovation. "von Foerster explained the purpose of the class is 'to find solutions to problems with constraints. If you want to regulate a system you must understand it,' he said. 'Students are concerned with the deep problems of society.'" (Clarke quoting a newspaper report from the time, quoting von Foerster.)

The publications von Foerster and his students created reflect his turn to "the systems counterculture." Clarke notes, "The systems counterculture's broad cultural effect has been to detoxify the notion of 'system' of its military, industrial, and corporate connotations of command and control and to redeploy it in the pursuit of holistic ideals and ecological values." (Bruce Clarke, "From Information to Cognition: The Systems Counterculture, Heinz von Foerster's Pedagogy, and Second-Order Cybernetics," *Constructivist Foundations*, Vol. 7, No. 3, 2012, 197.)

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Fred Turner, *From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism* (Chicago: University of Chicago Press, 2006), 24.

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Heinz von Foerster, ed., "A Note from the Editors," in *Cybernetics: Circular Causal and Feedback Mechanisms in Biological and Social Systems, Transactions of the Eighth Conference* (New York: Josiah Macy Jr. Foundation, 1952), 321.

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Norbert Wiener, *The Human Use of Human Beings: Cybernetics and Society* (New York: Houghton Mifflin, 1950), 15.

8
Norbert Wiener, *Cybernetics: or Control and Communication in the Animal and the Machine* (New York: Wiley, 1948), 11.

9
Wiener, *The Human Use of Human Beings*, 16.

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Claude Shannon, "A Mathematical Theory of Communications," *The Bell System Technical Journal*, 27 (July-October 1948), 379-423, 623-656.

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Vannevar Bush, "As We May Think," *Atlantic Monthly*, (July 1945): 2, accessed April 12, 2015, http://www.theatlantic.com/ideastour/technology/bush-full.html.

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von Foerster, "A Note from the Editors," in *Cybernetics*, 322.

13
Gordon Pask, *An Approach to Cybernetics*, (London: Hutchinson, 1961), 6.

14
Turner, *From Counterculture to Cyberculture*, 27.

15
Margaret Mead, "Cybernetics of Cybernetics," in *Purposive Systems: Proceedings of the First Annual Symposium of the American Society for Cybernetics*, ed. in Heinz von Foerster et al, (New York: Spartan Books, 1968), 4-5.

16
Stewart Brand, "For God's Sake, Margaret," a conversation with Margaret Mead and Gregory Bateson, *CoEvolutionary Quarterly*, 10. No. 21(June 1976), 32-44, accessed April 12, 2015, http://www.oikos.org/forgod.htm.

17
von Foerster, ed., "A Note from the Editors," in *Cybernetics*, 321.

18
Heinz von Foerster, original manuscript (December 12, 1951) supplied by Albert Müller of the von Foerster Archive, was published in edited form and referenced in note 6.

19
Mead, "Cybernetics of Cybernetics," in *Purposive Systems*, 10.

20
Brand, "For God's Sake, Margaret," 12-13.

21
Heinz von Foerster, "Ethics and Second-order Cybernetics," in *Understanding Understanding, Essays on Cybernetics and Cognition*, (New York: Springer-Verlag, 2003), 316.

22
Turner, *From Counterculture to Cyberculture*, 120.

23
Humberto Maturana, "The Neurophysiology of Cognition," in *Cognition: A Multiple View*, ed. P. Gavin (New York: Spartan Books, 1969), 4.

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Humberto Maturana, "Metadesign," (paper presented at Instituto de Terapia Cognitiva (INTECO), Santiago, Chile, August 1, 1997), n.p., accessed April 12, 2015, http://www.inteco.cl/articulos/006/texto_ing.htm.

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Bernard Scott, "The Cybernetics of Gordon Pask," in Gordon Pask, *Philosopher Mechanic: An Introduction to the Cybernetician's Cybernetician*, ed. Ranulph Glanville and Karl H. Müller, (Vienna: Edition Echoraum, WISDOM), 41.

26
von Foerster, "Cybernetics of Cybernetics", in *Purposive Systems*, 266.

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Maturana, "Metadesign."

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Ibid.

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Scott, "The Cybernetics of Gordon Pask," 41.

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Ross Ashby, "Design for a Brain," *Electrical Engineering*, 20 (1948), 379.

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Andrew Pickering, *The Cybernetic Brain: Sketches of Another Future*, (Chicago: University of Chicago Press, 2010), 19.

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J.C.R. Licklider, "Man-Computer Symbiosis," *Transactions on Human Factors in Electronics*, (March, 1960), 4.

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J.C.R. Licklider, "The Computer as a Communication Device," *Science and Technology*, (April 1968), 21.

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Albert Müller, "A Brief History of the BCL, Heinz von Foerster and the Biological Computing Laboratory," in *An Unfinished Revolution?* (Vienna: Edition Echoraum, 2007), 279.

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Pickering, *The Cybernetic Brain*, 237.

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Müller, "A Brief History of the BCL: Heinz von Foerster and the Biological Computing Laboratory," 294.

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Turner, *From Counterculture to Cyberculture*, 26.

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Pickering, *The Cybernetic Brain*, 6-7.

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Ted Nelson, correspondence with author Hugh Dubberly, March 21, 2015.

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Theodore H. Nelson, *Dream Machines / Computer Lib*, (1974), 82 (DM 47).

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Pickering, *The Cybernetic Brain*, 18.

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Turner, *From Counterculture to Cyberculture*, 43.

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John Markoff, *What the Dormouse Said: How the Sixties Counter-culture Shaped the Personal Computer Industry*, (London: Penguin, 2003).

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Ted Nelson, correspondence with author Hugh Dubberly, March 21, 2015.

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Stewart Brand, correspondence with author Hugh Dubberly, January 31, 2015.

Louise Sandhaus brought our attention to an example of Wiener's influence on the arts. In his 1970 book *Expanded Cinema*, Gene Youngblood writes about the "cybernetic movie studio" and the "transition from the Industrial Age to the Cybernetic Age," which he calls "Paleocybernetic"—combing "the primitive potential associated with Paleolithic and the transcendental integrities of 'practical utopianism' associated with Cybernetic … an image of a hairy, buckskinned, barefooted atomic physicist with a brain full of mescaline and logarithms…. It's the dawn of man: for the first time in history we'll soon be free enough to discover who we are." (See Gene Youngblood, *Expanded Cinema*, New York: E.P. Dutton, 1970, 41.) Buckminster Fuller wrote the introduction, and Stewart Brand included a review in the *Whole Earth Catalog*.

Later, Youngblood met members of the "second generation" of cybernetics and began a book (never completed) on Humberto Maturana and Francisco Varela. Youngblood reports, "Their theory of autopoiesis and the second-order cybernetics that Heinz [von Foerster] derived from it, changed my life. At last, I felt, here was biological (not just philosophical) proof of the impossibility of objectivity, the foundation of the mass media's bogus legitimacy. Later, I became more interested in autopoiesis as a framework for talking about autonomy, which Maturana/Varela explicitly acknowledged, and which I use to this day." (Gene Youngblood correspondence with author Paul Pangaro, July 27, 2015.)

47
In 1969, Frank Oppenheimer imported *Cybernetic Serendipity* to San Francisco as the opening exhibition of his ground-breaking interactive learning environment, the Exploratorium. Its cavernous, unfinished interior created an appropriately immersive environment for the city that spawned Haight-Ashbury and other beacons of counter-culture. This began a long history of public exhibitions that amplified curiosity and encouraged the trial-and-error, cybernetic approach that Oppenheimer championed. His vision was a new type of learning for an age of social experimentation, bringing together art and science to foster an experiential understanding of phenomena in the world through interaction.

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Stewart Brand, *The Last Whole Earth Catalog: Access to Tools*, (Menlo Park, CA: Portola Institute, 1973), 1.

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Steve Jobs, Stanford University Commencement Address, June 14, 2005, accessed April 12, 2015, http://news.stanford.edu/news/2005/june15/jobs-061505.html.

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Turner has chronicled the influence of cybernetics on Brand, Fuller, and McLuhan, and how it led to "cyberculture." For example, Alan Kay took the PARC librarian to the Whole Earth Truck Store, and "they bought a copy of every book there." See Fred Turner, *From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism*, (Chicago: University of Chicago Press, 2006), 112.

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Stewart Brand, correspondence with author Hugh Dubberly, January 31, 2015.

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Buckminster Fuller, *Ideas and Integrities: A Spontaneous Autobiographical Disclosure* (New York: Macmillan, 1969).

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Chanpory Rith and Hugh Dubberly, "Why Horst W.J. Rittel Matters," *Design Issues*, vol. 23, no. 4, (Autumn 2006), 72-91.

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Ashby's work is particularly important for its comprehensiveness and rigor. In addition to Design for a Brain, his *Introduction to Cybernetics* (London: Chapman & Hall, 1956) is important because it defined the concept of "variety" as a measure of the degree of a system's ability to respond to disturbances. By extension, a system has "requisite variety" (RV) if it can maintain homeostasis in the face of a range of disturbances. RV is an important contribution with many implications—for systems theory and modeling directly, and also for design and ethics. For design, RV provides a way to rationally frame the questions: What is "good enough?" And who needs to be involved? For ethics, RV is a foundation for von Foerster's "ethical imperative."

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Pickering, *The Cybernetic Brain*, 157.

56
Chuck Owen, correspondence with author Hugh Dubberly, April 1, 2015.

57
Ralph Caplan, correspondence with author Hugh Dubberly, March 28, 2015.

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Pickering, *The Cybernetic Brain*, 382.

59
Gordon Pask, "The Architectural Relevance of Cybernetics," *Architectural Design*, (1969) 494.

60
Ibid.

61
Ranulph Glanville, "A (Cybernetic) Musing: Design and Cybernetics," *Cybernetics and Human Knowing*, (Vol. 16: 3-4, 2009), 175.

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Usman Haque, "The Architectural Relevance of Gordon Pask," *Architectural Design*, 77, no. 4 (July/August 2007), 54-61.

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Horst Rittel, "On the Planning Crisis: Systems Analysis of the 'First and Second Generations'." Bedrifts Økonomen. 8 (1972), 394.

64
Pask, "The Architectural Relevance of Cybernetics," 494.