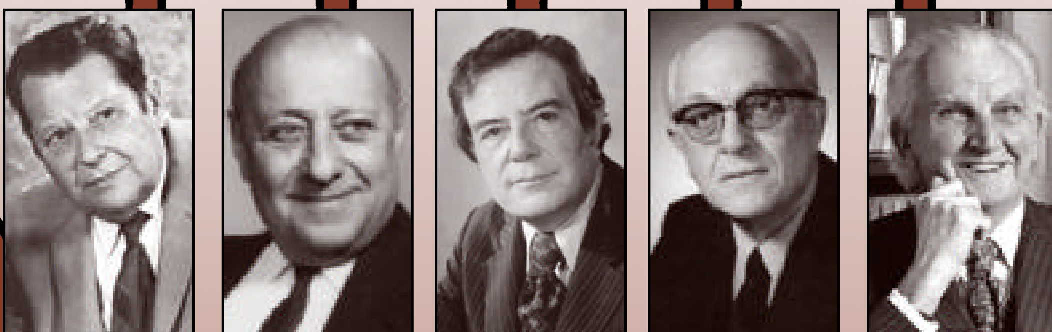
Debora Hammond



The Science of Synthesis

Exploring the Social Implications of General Systems Theory

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To my parents, Don and Whitty Hammond

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Preface

> The Civilization of the Dialogue is the only civilization worth having and the only civilization in which the whole world can unite. It is, therefore, the only civilization we can hope for, because the world must unite or be blown to bits. The Civilization of the Dialogue requires communication. It requires a common language and a common stock of ideas. It assumes that every man has reason and that every man can use it. It preserves to every man his independent judgment and, since it does so, it deprives any man or any group of men of the privilege of forcing their judgment upon any other man or group of men. The Civilization of the Dialogue is the negation of force. We have reached the point, in any event, when force cannot unite the world; it can merely destroy it. Through continuing and enriching the Great Conversation, higher education not only does its duty by morals and religion, it not only performs its proper intellectual task; it also supports and symbolizes the highest hopes and the highest aspirations of mankind.
>
> —Robert Maynard Hutchins[1]

I would like to think of this book as a sort of conversation, into which I hope you, the reader, might also be drawn. It began as a graduate research project, examining the work of five individuals, all Grand Old Men in American intellectual history, who founded the Society for General Systems Research in 1954—Ludwig von Bertalanffy, Kenneth Boulding, Ralph Gerard, James Grier Miller, and Anatol Rapoport. It is appropriate to begin with Hutchins and his vision of the Civilization of the Dialogue. As president of the University of Chicago in the early twentieth century, Hutchins provided visionary leadership, fostering innovative interdisciplinary approaches to scholarship and teaching. All five founders were nurtured in this exciting and fertile intellectual environment at some point in their academic career. Hutchins's influence lives on in a liberal studies program at the Sonoma campus of the California State University system, where I have been teaching for the last five years after completing my doctorate at UC Berkeley in 1997. The Hutchins School of Liberal Studies is dedicated to interdisciplinary inquiry and an interactive seminar-based pedagogy, engaging the student as an active participant in the learning process. It embodies the commitment to dialogue and mutual understanding to which Hutchins appeals, an essential first step in creating a sustainable and enduring civilization.[2]

Originally written as a dissertation in the history of science, this project traces the emergence of the concept of systems as a theoretical framework in the physical sciences, the life sciences, and the social sciences (although some consider the latter an oxymoron). Like the Center for Advanced Study in the Behavioral Sciences, where the idea for the society was born, the Society for General Systems Research was an attempt to nurture conversation across a broad spectrum of disciplines, in the tradition of Hutchins and the Great Conversation, about the systems that condition our lives. In examining the intellectual biographies of the five founders, it recounts the story of a unique episode in the history of modern thought, an episode both poorly understood and worthy of reassessment.

Almost half a century ago, C. P. Snow lamented the inability of the "two cultures" to understand each other. This is unfortunately still the case; academic discourse has become increasingly polarized, reflected in the so-called science wars—between contemporary science/technology and its deconstructionist or social constructionist critics, between propriety research and ethical concerns, and even between the evolutionists and the creationists. Although the academic community prides itself on tolerance, it often fails to recognize its own exclusionary practice. What passes for dialogue in the media amounts to sound-bite shouting matches; if we are to survive, we must learn how to listen to each other with a commitment to mutual understanding and respect.

As I write, we are approaching the first anniversary of the attacks on the World Trade Center and the Pentagon—two key symbols of American wealth and power. At the time, many compared this event with the bombing of Pearl Harbor in 1941, inviting reflection on what we may or may not have learned in the last six decades. Among the many institutions established after World War II to address the challenges of the new era, the Center for Advanced Studies in the Behavioral Sciences (CASBS) was funded by the Ford Foundation to foster interdisciplinary research on the roots of conflict and the possibilities for democratic solutions to economic and political problems confronting the world community. At the dawn of the twenty-first century, such concerns are even more pressing.

The Society for General Systems Research (SGSR) was one of several organizations that grew out of associations formed during CASBS's first year (1954–1955). This book begins by tracing the emergence of systems theory in the 1940s and 1950s as an organizing concept across a broad spectrum of disciplines: organismic biology, gestalt psychology, engineering, management, cybernetics, information theory, ecology, and social theory. It then explores the backgrounds and motivations of the five founding fathers, focusing on the relevance of their work in addressing the growing challenges to democracy, and assessing the social and political significance of systems ideas in decisionmaking processes in business and government.

In the course of my research on the history of systems thinking, I found a variety of divergent traditions. As I struggled to get a handle on the concept, I was fortunate enough to meet West Churchman, professor emeritus of business at UC Berkeley and longtime systems thinker, in the spring of 1993. When I mentioned my interest in the history of systems theory, he said, "It all began with four people [Bertalanffy, Boulding, Gerard, and Rapoport] who met in 1954 at the Stanford

Center for Advanced Study in the Behavioral Sciences." I have included James Miller in my story because he worked closely with Gerard and Rapoport and contributed substantially to the formation and evolution of the SGSR. Although it is only one of many systems-oriented institutions that emerged during this era, the general systems community reflects concerns similar to my own and turns out to have been an ideal focus for my research; it was and still is a unique and diverse group of individuals who have sought to foster meaningful conversation and to nurture authentic interdisciplinary synthesis. Recent work in this tradition provides compelling evidence of the sort of inclusive and participatory approaches to systems thinking I had hoped to discover in my research.

Nevertheless, this is by no means an exhaustive treatment of even the general systems tradition. Recently I received a letter from a former member of SGSR, Donald McNeil. Having read my dissertation, he commented that my work provides a "substantial contribution to an understanding of what went into the general systems movement," although a complete story would include chapters on Ross Ashby, Heinz von Foerster, Stafford Beer, Russell Ackoff, and West Churchman, as well as sections on Ervin Laszlo, Erich Jantsch, Jay Forrester, Ralph Abraham, Stuart Kauffman, Robert Rosen, Louis Kauffman, and Humberto Maturana. In limiting my scope to the visions and work of the original founders and focusing primarily on the social significance of the systems concept, I have neglected important developments in the tradition, which might provide the focus for a future volume.

McNeil also suggests that my work provides a postmortem for the historical record now that the movement is moribund. I disagree. Ideas go in and out of vogue; a recent issue of *Science* (March 2002) features articles on new developments in systems biology. The introduction opens with a quote from Bertalanffy: "If someone were to analyze current notions and fashionable catchwords, he would find 'systems' high on the list. The concept has pervaded all fields of science and penetrated into popular thinking, jargon, and mass media." The authors then note that "this is a trend with remarkable staying power, for the words quoted above were written not for today's issue of *Science,* but rather in Ludwig von Bertalanffy's 1967 introduction to his book, *General System Theory,* a compilation of his writings, some of which date back to 1940!"[3]

Systems ideas are resurfacing in a variety of contexts. Fritjof Capra has written extensively on the social significance of systems concepts. Peter Senge includes systems thinking as an essential component in his discussion of businesses as "learning organizations." Systems concepts are gaining currency, as well, in the sustainability movement and the philosophy of deep ecology, both of which highlight the interdependent nature of relationships between the individual, society, and the natural environment. From economic and political perspectives, Allan Savory, *Holistic Management: A New Framework for Decision Making;* David Korten, *The Post-Corporate World;* and Paul Hawken and Amory and Hunter Lovins, *Natural Capitalism,* all draw heavily on systems concepts. Whatever the context, the systems concept highlights the importance of inclusive and collaborative approaches to understanding ourselves in relation to the social, ecological, and technological dimensions of our lives.[4]

Initially, my vision for graduate work entailed an exploration of the relationship between emerging paradigms in science and what I saw as a renaissance of the feminine, so it is ironic that I have chosen to write about a group of five men. It seems to be fashionable to dismiss the potentially progressive contributions of such groups, growing as they do out of elite old-boy networks. On the other hand, the work of the general systems community has laid a foundation upon which a more inclusive approach to social organization might be built. During the past five years I have become increasingly interested in what I have called the "qualitative dimension of relationship." It struck me that, although systems thinkers generally emphasize the importance of understanding relationships within and between different kinds of systems, they often address such relationships in fairly abstract terms. Far more important, in my view, is the way in which our institutions condition our interpersonal relationships, in terms of the kinds of behavior that is rewarded and how we actually treat one another. Such concerns are at the heart of what I would consider a feminist approach to systems, and some important insights along these lines can be found in the work of these men, the value of which transcends the possible taint of their association with a privileged elite. Like living systems, ideas are capable of evolution and self-transcendence.

NOTES

1. I am unable to locate the exact source for this passage; I have included it on the syllabus for my Introduction to Liberal Studies course since 1996. See Hutchins, *The Great Conversation: The Substance of a Liberal Education,* vol. 1: *The Great Books of the Western World* (Chicago: Encyclopaedia Britannica Inc., 1952). Hutchins's emphasis on the importance of dialogue and inquiry is laudable, although I disagree with his contention that "no dialogue in any other civilization can compare with that of the West in the number of great works of the mind that have contributed to this dialogue" (*Great Conversation,* p. 1). This view has in fact impoverished the dialogue and endangered the world community in failing to cultivate an attitude of inclusion and mutual respect, which I consider an essential quality of an authentic "Civilization of the Dialogue."

2. I use the term "American" advisedly. Bertalanffy was from Austria and worked in Canada for most of the latter half of his career. Boulding was born into the working class in England and won a scholarship to Oxford; he also taught in Canada before moving to the United States. Rapoport was Russian, moving to the United States at the age of eleven and relocating to Canada later in life. The SGSR was an international society from its inception, with active members from the southern half of the Western Hemisphere as well as the northern. Nevertheless, it was the unique academic and cultural context in the United States at the time that fostered the group's collaborative efforts, and thus I describe it as an "American" tradition, despite the limitations and inaccuracies of that term.

3. Lisa Chong and L. Bryan Ray, "Whole-istic Biology," *Science* 295 (March 1, 2002): 1661, citing Bertalanffy, *General System Theory* (New York: George Braziller. 1969).

4. Fritjof Capra, *The Turning Point: Science, Society, and the Rising Culture* (New York: Simon & Schuster, 1982) and *The Hidden Connections: Integrating the Biological, Cognitive, and Social Dimensions of Life into a Science of Sustainability* (New York: Doubleday,

2002); Peter Senge, *The Fifth Discipline: The Art and Practice of the Learning Organization* (New York: Doubleday, 1990); Allan Savory, *Holistic Management: A New Framework for Decision Making* (Washington, DC: Island Press, 1999); David Korten, *The Post-Corporate World* (San Francisco: Berrett-Koehler, 1999); and Paul Hawken, Amory Lovins, and Hunter Lovins, *Natural Capitalism: Creating the Next Industrial Revolution* (Boston: Little, Brown, 1999), especially the section on "Capitalism as if Living Systems Mattered," pp. 177–183.

ACKNOWLEDGMENTS

I am grateful to West Churchman for introducing me to the unique group of scholars who coalesced around Bertalanffy's concept of general systems theory. I owe a tremendous debt of gratitude to Carolyn Merchant, the chair of my dissertation committee at UC Berkeley, for her wholehearted support. She has been an inspiring role model, mentor, and friend. Thanks are also due to the other members of my committee—David Hollinger, Jack Lesch, and Arnold Schultz—all of whom enriched the breadth of my perspective in tracing the emerging panoply of ideas that constellated around the concept of systems in the middle decades of the twentieth century. Fritjof Capra and Joanna Macy, visionary mentors from the larger community, provided considerable guidance and inspiration.

Miller and Rapoport are the only two of the original founders who are still living. I am grateful for the opportunity to meet with both of them. Miller and his wife, Jessie, invited me into their home on two occasions and were most generous in sharing materials relating to the society's history. Jessie herself contributed substantially to the publication of Miller's *Living Systems* and I was very sorry to hear of her recent passing. She is one of the many women of systems who also deserve recognition. I also had an opportunity to meet briefly with Boulding's wife, Elise; though not active in the systems community, she is an accomplished scholar and dedicated peace activist in her own right.

I could not begin to name all of the current and former members of the International Society for the Systems Sciences (ISSS; formerly the SGSR) who graciously shared their understanding of systems and their reflections on the accomplishments and challenges of their collective history. I am particularly grateful to the Banathys (Bela H. and Bela A.) for supporting my work and inviting me to present my ideas in ISSS plenaries and the *Systems Research and Behavioral Science* journal. Other members who have been especially helpful include Arne Collen, Gordon Dyer, Yoshi Horiuchi, Alexander and Kathia Laszlo, John Li, Hal Linstone, Harold Nelson, Linda Peeno, Bill Reckmeyer, Miriam Tausner, Len Troncale, Elizabeth White, and Jennifer Wilby.

And for invoking the muse, I would like to thank Darrin Pratt at the University Press of Colorado; he has been a kind and patient guide on the journey. Thanks, also, to Laura Furney, for ushering the book through the production process; to my copy editor, Scott Vickers, for his careful attention to detail; and to my reviewers, whose comments and suggestions helped to both expand my perspective and sharpen my focus. Of course, I am responsible for whatever fuzziness remains, but I do not pretend to have the final word on systems. This is an invitation. Let the conversation begin.

Only that day dawns
To which we are awake
There is more day to dawn
The sun is but a morning star.

—Henry David Thoreau, *Walden*

PROLOGUE
The Quest for Peace in a Nuclear World

Though hate rises in enfolding flame
At each renewed oppression, soon it dies;
It sinks as quickly as we saw it rise,
While love's small constant light burns still the same.
Know this: though love is weak and hate is strong,
Yet hate is short, and love is very long.

—Kenneth Boulding[1]

These days it seems that Boulding had it wrong; love is so often short-lived and hatred seems deeply entrenched, particularly in the Middle East, where two ancient cultural traditions appear to be bent on mutual destruction. Still, I am hopeful that humanity may someday emerge from this dark chapter in our collective evolution to discover more harmonious ways of living together. We are seeing all around us the bankruptcy and corruption of our current system, a way of life that has placed productivity and profit above human well-being and the sustainability of life on this planet.

My own motivation in undertaking this project grew out of my involvement in the Nuclear Freeze campaign in the early 1980s. I simply could not understand why the United States was continuing to produce such profoundly destructive weapons when we already had more than enough to destroy the world thousands of times over. I sought to understand the assumptions about reality at the root of such seemingly irrational behavior. At the time I heard a lecture by Fritjof Capra, in which he argued that the problems we face as a society (including the arms race, poverty, violence, crime, environmental degradation—and now terrorism) are systemic problems, resulting from a crisis in perception, rooted in the mechanistic model that has dominated scientific thought since the seventeenth century. In contrast to this mechanistic world view, Capra emphasized the importance of a more ecological or systemic conception, based on an understanding of our fundamental interconnectedness and interdependence, with each other and with all of life.[2]

This perspective on the relationship between the philosophical foundations of mechanistic science and the sociopolitical developments of the postwar era echoed my own growing sense that the greatest obstacles to the goals of peace and disarmament were limitations in the scientific framework underlying Western conceptions of reality and rationality. Returning to graduate school in 1989 to study the history of science, I was interested in understanding how theoretical frameworks in science shape our perception of reality, in turn affecting how we think about society and how we organize our social institutions. Similar concerns are reflected in the work of a number of contemporary writers. Margaret Wheatley, for example, argues that our social institutions are founded on the assumptions of Newtonian physics and the corresponding desire to maintain control, despite current developments in quantum mechanics, chaos theory, and self-organizing systems, which she believes support a more collaborative approach to organization. Mae-Wan Ho suggests that the basic paradigm of science is shifting from the machine metaphor to the metaphor of self-organizing systems, and that such a shift might change how we design our economic institutions. In his latest book, Capra explores the systemic nature of life, mind, and society as a foundation for a more sustainable culture.[3]

Although the rise of mechanistic science in the seventeenth century is often associated with the emergence of political democracies in the West, this dual heritage from the Enlightenment contains an inherent dialectical tension. As critical theorists in the Frankfurt School have argued, the promise of progress through the control of nature ultimately entails the control of human nature, undermining the liberating impulse of democracy and the ideals of social justice that are also part of the Enlightenment tradition. In seeking to address the limitations of mechanistic science, the heroes of my tale are not advocating a return to an earlier or antiscientific view, as much as they are challenging science to transcend its own limitations, to evolve and adapt to the changing conditions of its environment, and to develop a more expanded and inclusive sense of self-consciousness as a critical force in shaping the social order.[4]

The two most noteworthy architects of mechanistic science are René Descartes and Sir Isaac Newton. Descartes described the phenomenal universe as matter in motion, which could be represented in abstract mathematical terms. He also articulated a dualistic relationship between mind and matter, reinforcing Aristotle's distinction between active and passive principles, and the Church's radical separation of spirit and flesh. Newton elaborated fundamental laws of motion regulating the interactions of matter. Uniting the previously incommensurable terrestrial and celestial spheres, his law of gravity ultimately laid the groundwork for a totally materialistic conception of the universe.

As the father of general systems theory, Ludwig von Bertalanffy was outspoken in his criticism of mechanistic science. Like Mae-Won Ho, he proposed a more organismic approach to the study of complex systems, objecting to the narrow reductionism of classical science. Rooted in Descartes's analytic approach, reductionist science studies natural phenomena by “reducing” them to their smallest components. While a great deal can be learned through such techniques, the scientific enterprise lacks an integrative framework to put the pieces back together again. When the focus is on the parts, and systems at higher levels of organization—individuals, societies, and ecosystems—are understood as essentially determined by these component parts, such concepts as wholeness, autonomy, and integrity become meaningless. From critical analysis to nuclear fission, we have learned well the lessons of taking things apart. Now we must begin to learn the principles of synthesis, how to put the pieces back together and create wholeness—not the rigid totalitarian wholeness that critics of holistic models fear, but a dynamic, co-creative, self-renewing, and self-transcending wholeness—a truly inclusive unity in diversity.

In this context then, I approached systems theory as a possible alternative to mechanistic thinking that might foster the kind of transformation in consciousness humanity needs in order to create a more peaceful and equitable world. As a result, I was puzzled by critiques coming out of the academic community. Depicting systems theory as a kind of technocratic ideology, these critics argued that it was responsible for creating and justifying an increasingly hierarchical social order. For Bertalanffy, however, it was the poverty of reductionism, particularly the “robot model” of humanity in behaviorist psychology, that was responsible for the totalitarianism and militarism of the postwar era. The primary question I sought to address in my research was whether systems approaches are inherently technocratic, reinforcing hierarchical and centralized organizational structures as the critics claimed, or if there might be examples of systemic approaches to the design and organization of social structures that could support a more participatory, inclusive, and truly democratic social order.

Critics tend to equate the concepts of “systems theory” and “systems thinking” with “systems analysis,” as developed by the RAND Corporation and other government-funded think tanks during the Cold War years. While some members of the Society for General Systems Research (SGSR) were involved with military and industrial applications of systems models, the dominant current of work within the group reflects a concern with the development of more collaborative approaches to decisionmaking within social systems. The founders of the SGSR shared many of my own concerns and sought alternatives to the growing power of the military-industrial complex and the increasingly dehumanizing tendencies of the emerging technocracy.

Both Kenneth Boulding and Anatol Rapoport were harshly critical of the military-industrial complex and became outspoken opponents of the Vietnam War. They worked together to develop the disciplinary field of peace research and established the Center for Peace Research and Conflict Resolution at the University of Michigan in 1956. In relation to their work in this field, Rapoport was most well known for his work on non–zero-sum models in game theory, and Boulding considered dialogue and participatory decisionmaking as key elements in any conception of peace. As an economist, Boulding was one of the first to incorporate ecological considerations, and his foundational work in ecological economics was integrally connected with his research on peace and social justice.

Echoing this integrative perspective, Wendell Berry proposes an analysis of the kind of science that has supported such destructive relationships both among humans and between the human community and the natural world: "Apparently everywhere in the 'developed world' human communities and their natural supports are being destroyed . . . by a sort of legalized vandalism known as 'the economy.' The economy now famously depends upon the authority and applicable knowledge of science. It would therefore be useful to say what is the character of this science that has benefitted us in so many ways, and yet cost us so dearly and extracted from us such deferences and such questionable permissions." Such is the question I have attempted to explore in greater depth through the lens of the general systems community.[5]

Further, it is important to consider what might be the nature of such a science that could foster more harmonious relationships. The founders of the SGSR offer some provocative suggestions along these lines. An appreciation of the interconnections between the various dimensions of our lives (social, political, economic, psychological, biological, and technological) and between corresponding disciplinary perspectives is a critical first step. Berry underscores the need for "authentic conversation" among the disciplines. The following is an account of an ambitious attempt to foster such a conversation, with some significant implications for our own time.

NOTES

1. Kenneth Boulding, from *There Is a Spirit: The Naylor Sonnets* (New York: Fellowship Press, 1945).

2. Fritjof Capra, *The Turning Point* (New York: Simon and Schuster, 1982), p.16.

3. Margaret Wheatley, *Leadership and the New Science* (San Francisco: Berrett-Koehler, 1992); Mae-Wan Ho, cited in David Korten, *The Post-Corporate World* (San Francisco: Berrett-Koehler, 1999), p. 103; Fritjof Capra, *The Hidden Connections: Integrating the Biological, Cognitive, and Social Dimensions of Life into a Science of Sustainability* (New York: Doubleday, 2002).

4. See Max Horkheimer and Theodor Adorno, *Dialectic of Enlightenment,* trans. John Cumming (New York: Herder and Herder, 1972); and William Leiss, *The Domination of Nature* (New York: George Braziller, 1972).

5. Wendell Berry, *Life Is a Miracle: An Essay Against Modern Superstition* (Washington, DC: Counterpoint, 2000), p. 23.

ONE The Behavioral Sciences in Postwar America

> In a world whose people are becoming rapidly more interdependent and in which the external forces that control them are becoming more centralized, there is urgent demand for a rational basis for planning and responsible decisionmaking. At the same time, individuals require an understanding of human behavior if they are to help maintain the democratic nature of such planning and control.
>
> —Ford Foundation Report, 1948[1]

Like my own quest to understand the rationale behind the seeming irrationality of the nuclear arms race, the founding of the Center for Advanced Study in the Behavioral Sciences (CASBS) in 1954 was motivated by a sense of urgency in the face of the new technologies of destruction and the polarization of the world into two increasingly adversarial camps. The opening quote reflects the primary concern of the Ford Foundation in establishing the center, still critically relevant fifty years later—how to maintain a democratic society in an increasingly complex and dangerous world.

Originally established in 1936, the Ford Foundation was faced with the task of distributing a considerable sum of money after Henry Ford's death in 1947. Kenneth Boulding playfully describes the situation in the following excerpt from an unpublished poem entitled "Sam Small at the Center":

> So straightway the great Ford Foundation
> Got into a bit of a stew,
> And set up a sort of committee
> To tell it just what good to do.
> The committee was very distinguished,
> And took all the world in its scan;
> They sought for the cause of our troubles,

And found it was likely in man.
And most of them being Perfessors,
They said, without making much fuss,
"If yer want to do good with yer munny,
Yer might as well do it to us."
And that's 'ow the great Ford Foundation
Got this idea dumped in its lap,
To set up a sort of a Center
For studying Old Homo Sap.[2]

A 1948 report commissioned by the trustees reflects the atmosphere of postwar America in its five-point program to support activities that would contribute to (1) world peace and a world order of law and justice, (2) greater allegiance to the basic principles of freedom and democracy, (3) economic well-being of people everywhere, (4) improved educational opportunities, and (5) increased knowledge of factors that influence or determine human conduct, and the extension of such knowledge for the maximum benefit of individuals and society.[3]

The fifth program area, entitled "Individual Behavior and Human Relations," resulted in the establishment of CASBS, bringing together experts from a wide array of disciplines in order to promote interdisciplinary research and improve the training of professionals in the scientific study of human behavior. For the foundation, this meant studying values, learning processes, communication, group organization, cooperative efforts, and individual satisfaction, and applying the resulting knowledge in planning and policymaking in business and government. The first year was particularly fruitful in generating a number of ongoing interdisciplinary programs including, of course, the Society for General Systems Research (SGSR). With the exception of Ludwig von Bertalanffy, all of the founders of SGSR had been actively involved in the planning process for the center, reflecting the close alignment between the goals and general orientation of both organizations.

While it is easy, in retrospect, to be cynical about such lofty aims—and Boulding's verses hint at the potentially self-serving nature of such endeavors—the scholars who were brought together during CASBS's first year seemed to share a sense of mission and purpose comparable to that of the social activists of the 1960s. In its broad interdisciplinary scope as well as its perceived urgency, CASBS's program of behavioral science research was often compared to the Manhattan Project. Critics have pointed out the irony of using the latter as the model for social-science research given the immensity of the destruction it unleashed. Also, in spite of the appeal to democracy, the idea of scientific planning and control of society clearly justifies concerns that such research efforts were in fact profoundly undemocratic and accounts to some extent for the perception of systems theory as a form of technocratic ideology.[4]

Despite such concerns, the increasing complexity of technological developments in the first half of the twentieth century stimulated a tremendous growth of interest in interdisciplinary research projects and problem-solving efforts. This process was intensified by World War II and the growing role of social scientists in the government and military. A number of important theoretical and technological developments were catalyzed by the war, including cybernetics, information and communication theory, decision theory, game theory, operations research, management science, and computer technology. The parallels between these fields and emerging ideas about organizational processes in biological and social systems fostered considerable cross-fertilization in a wide variety of academic disciplines.[5]

The CASBS was a microcosm of this explosion of interest, and while its primary purpose was to bring together scholars in the behavioral sciences, which included biology, psychology, and the social sciences, all of these fields were dramatically affected by wartime developments in technology and management. During the first half of the twentieth century, most of the support for interdisciplinary research on human behavior had come from the Rockefeller and Carnegie Foundations. After World War II, the Ford Foundation provided the major source of funding, along with increasing contributions from corporations and government. Ford was also responsible for popularizing the concept of behavioral science, a term coined by James Grier Miller in 1949 to reflect the goal of integrating the biological, psychological, and social dimensions of human behavior. Significantly, in an era when social scientists were seeking governmental recognition and support, the name allayed fears of U.S. Senate members who were distrustful of the term "social science" because it sounded too much like "socialism." For those inclined toward skepticism, however, the term evoked associations with behaviorism and social control.[6]

According to James Thompson and Donald Van Houten, in their survey of the new field, behavioral science arose out of a dissatisfaction with the fragmentation among the various disciplines relating to the study of human society and culture. They describe its central concerns as reflected primarily in the fields of psychology, sociology, and anthropology, and to a lesser extent in economics, political science, and biology. While it is often associated with a hard, quantitative approach, emphasizing microphenomena, they point out that it is based on a macro focus in which human behavior is seen to be highly complex, involving interactions among many factors. Thompson and Houten identify three basic approaches to behavioral science research based on three different models of humanity, which will be important to keep in mind as we explore the social implications of systems thinking. The first emphasizes conflict in human relationships, the second portrays human behavior in mechanistic terms, and the third, most closely related to the general-systems view, understands humans as open systems. In the latter approach, which reflects the hermeneutic or interpretive tradition in the social sciences, humans are conceived as active agents rather than passive pawns, highlighting the importance of purposive behavior and cognitive processes, including perception, interpretation, and construction of meaning.[7]

Richard Jessor, director of the Institute of Behavioral Science at the University of Colorado where Boulding spent the second half of his professional career, describes the field as an emerging paradigm for social inquiry. According to Jessor, behavioral-science inquiry attempts to encompass both person and environment and to understand their interactions. Further, it tends to be methodologically pluralistic, seeking to integrate both hermeneutic and quantitatively oriented data-gathering approaches in the study of social phenomena. In addition, he notes that behavioral-science research tends to focus on significant social problems.[8]

Such focus is apparent in the programs that Bernard Berelson, director of Ford's Behavioral Science Division, identifies as the primary centers of behavioral-science research in the mid-twentieth century. These include Harvard's Department of Social Relations, graduate schools of business and industrial relations at the University of California and Cornell, Columbia University's Bureau of Applied Social Research, the Survey Research Center and the Mental Health Research Institute at the University of Michigan, and several programs at the University of Chicago. These centers were organized to facilitate research that cut across traditional departmental lines and were characterized by large-scale social research on such issues as community change, human development, public health, and social attitudes.[9]

The University of Chicago was one of the most important centers for interdisciplinary research in the social sciences, and its behavioral-science community was very influential in shaping the program of the Ford Foundation's Behavioral Science Division. As president and chancellor of the university from 1929 to 1951, Robert Maynard Hutchins did much to foster the interdisciplinary and innovative approaches to research that were embodied in the behavioral-science program. After leaving Chicago, Hutchins was associate director of the Ford Foundation's Behavioral Science Division until 1959, when he founded the Center for the Study of Democratic Institutions. In a collection of papers in honor of the twenty-fifth anniversary of the social-science building at the University of Chicago in 1955, Leonard White points out that Chicago was a pioneer in the development of the social sciences, implementing an urban research program in 1923 with Rockefeller support. The highly interdisciplinary Division of Social Sciences was established in 1931. It supported a broad range of approaches, some emphasizing values and philosophy and others focused on more quantitative analysis; some in favor of social and government reform and others with a more conservative, laissez-faire orientation. This range of diversity challenges most interpretations that tend to focus primarily on the positivistic aspect of the emerging field; as with systems theory, there was a tremendous variety of theoretical and political commitments in the behavioral sciences.[10]

The intellectual environment at the University of Chicago also had a lot to do with shaping the initial motivation of the founders of the SGSR, every one of them having spent some time there during the 1930s and 1940s. Ralph Gerard enrolled as a freshman in 1915, and became a member of the faculty in 1927. Anatol Rapoport began his studies there in 1937, joining the faculty ten years later. Miller was hired as chair of the Psychology Department in 1948. Boulding spent two years at Chicago, between 1931 and 1933, on a Commonwealth fellowship after he had finished the master's program at Oxford, and Bertalanffy was at Chicago on a Rockefeller fellowship in 1937–1938 and met Gerard at that time.

In association with Miller, Gerard and Rapoport were key participants in the Committee for the Study of the Behavioral Sciences that was established in 1949. The original motivation for this group grew out of a belief that the study of human behavior could benefit from the same kind of intensive research that led to the development of the atomic bomb. In fact, it was Enrico Fermi who encouraged Miller (as had Alfred North Whitehead at an earlier stage of his career) to work on an approach to the study of human behavior that would integrate biological and social dimensions. The primary purpose was to foster interdisciplinary research on problems of human behavior, although some have described it as an effort to develop the ability to manipulate and control human behavior, in response to a growing concern that the Soviet Union might be more advanced than the United States along these lines. Certainly the Behavioral Science Division of the Ford Foundation recognized a growing need for knowledge of human conduct in industry and government, reflected in increasing opportunities for professional careers in behavioral science.[11]

Ralph Tyler, who had been chair of the Social Sciences Division at Chicago, was appointed as the founding director of CASBS, and Gerard and Rapoport were both fellows at the center during that first year as representatives of Miller's Behavioral Science Committee. Miller himself would have been there except that he had procured funding from the state of Michigan to establish the Mental Health Research Institute at the University of Michigan, which would become the institutional center for the Society for General Systems Research until 1967. David Hollinger's characterization of Michigan during the postwar era as "a major site of the entrepreneurial transformation of American academia, and . . . of the intellectual revolutions in American social science associated with behavioral perspectives and quantitative methods" reflects a common, though limited, interpretation of the emerging science of human behavior. Such limited interpretations were also frequently applied to the concept of general systems theory that flowered in the fertile ground of Ford's new center.[12]

THE SOCIETY FOR GENERAL SYSTEMS RESEARCH

Early in the fall of 1954, four of the distinguished CASBS fellows—Bertalanffy, Boulding, Gerard, and Rapoport—sat together at lunch discussing their mutual interest in theoretical frameworks relevant to the study of different kinds of systems, including physical, technological, biological, social, and symbolic systems. According to Boulding, someone suggested that they form a society to foster interdisciplinary research on a general theory of complex systems, and thus the idea for the Society for General Systems Research (SGSR) was born.[13]

Bertalanffy had introduced the concept of general systems theory in a seminar at the University of Chicago in 1937. Prior to their year at the CASBS, Gerard and Rapoport had been working closely with Miller at the University of Chicago on an integrated theory of human behavior, and Boulding had been working on an interdisciplinary approach to the social sciences at the University of Michigan. Drawing on individual archives and records of the society, this book examines the work of these five founders in depth, in order to more clearly articulate the motivating vision behind the systems concept, as well as its potential significance in my own quest. In chronicling the activities and concerns of the society as it developed, I found a great deal of support for my original intuitive sense that the "systems view" had something to offer in the articulation and implementation of a more sustaining and sustainable vision of humanity's future.

Plans for the society were formulated at a session of the annual meeting of the American Association for the Advancement of Science held in Berkeley that December, and the SGSR was formally established in 1956. Renamed the International Society for the Systems Sciences (ISSS) in 1988, the society recently celebrated its forty-fifth anniversary. It represents a unique episode in the evolution of systems thinking, as one of the most broadly based of the systems-oriented institutions that emerged during the period.

The popularity of systems concepts in the mid-twentieth century arose out of a convergence of developments in both biological and technological fields, the latter giving rise to increasingly complex social organizations and furthering concern with the management of large-scale sociotechnical "systems," such as energy distribution, transportation, communication, and information networks. The SGSR emerged as part of this widespread and growing interest in the complexities of biological, social, and technological organization, drawing upon an impressive array of emerging conceptual frameworks in articulating a broader philosophical concern with the social and ethical implications of the new technologies.

The further evolution of general systems theory (GST) was closely intertwined with the development of the behavioral sciences in their mutual efforts to integrate insights from biology, psychology, and the social sciences in understanding human behavior, which was perceived as a particularly critical task in the context of the Cold War. An additional legacy from the World War II era was the emergence of cybernetics, information theory, computers, and highly sophisticated weapons technology, which profoundly shaped thinking on the nature of complex systems.

One of the primary goals of the general-systems group was to build on their perception of convergence in organizational processes toward a unity of science. They sought ways to overcome what they saw as the increasing fragmentation of knowledge and to build bridges across the ever widening chasms between the various ways of understanding our world, developing a new paradigm for scientific research that would cut across traditional disciplinary boundaries and provide models for integrating the physical, biological, psychological, and social sciences. The stated intention was to explore structural and functional similarities in systems at all levels of organization, seeking a kind of "general theory" of systems.

Systems theories thus emerge as a synthesis of developments in a variety of disciplinary fields, including the behavioral sciences as well as engineering and management. Drawing on their professional training in biology and the social sciences, the founders of the SGSR were all involved with the emerging field of behavioral science, focusing especially on the psychology of social organization. Over the course of its development, the society has increasingly focused on issues of management, and clearly the behavioral sciences lend themselves to applications in this area. Thus the motivating concerns and value commitments of the group, as well as the nature of the management models that emerged from their collaborative venture, became the primary focus in my quest to understand the social implications of their work.

For the founders of the society, systems theory was a theoretical framework that was holistic, taking into account the interrelationships and interdependence between the parts of a system, as well as the relationship between systems and their environments. They saw this approach as a significant departure from the more reductionist approach of traditional science, which sought to understand systems by breaking them down into their smallest parts, fragmenting knowledge about the world through the increasing specialization of separate disciplines that had very little interaction with each other. Although they acknowledged that specialized knowledge was important, they hoped to develop a workable framework for integrating different fields of study.

George Klir, member and former president of SGSR, writes, "A need for a better understanding of biological, psychological, and social phenomena initiated an interest in the study of systems with strong (non-negligible) interactions between their components, as well as between each system and its environment." He goes on to define general system theory as "a new way of looking at the world in which individual phenomena are viewed as interrelated rather than isolated, and complexity has become a subject of interest."[14]

CRITIQUE AND RESPONSE

While systems concepts and models were extremely popular and influential across a broad spectrum of disciplines during the 1960s and 1970s, they came to be viewed with increasing skepticism with the emergence of postmodern critiques of totalizing schemes and the growing disillusionment with the promise of technological progress that fueled the countercultural movement of the 1960s. Robert Lilienfeld's argument in *The Rise of Systems Theory* (1978), that the societal claims of the systems thinkers served only to justify the claims to power and prestige of the technocratic elite, is characteristic of more recent reactions to systems views among social scientists. For many, systems thinking came to be associated with the highly rationalized technological and institutional systems of the late twentieth century, and the concept of *system* became synonymous with control and totalization.[15]

Most critics of systems theory, however, tend to treat the development of systems thinking as an integrated and coherent phenomenon and to downplay the considerable diversity in the perspectives and ideological orientations of different approaches to understanding systems. Far from being monolithic, the "systems movement" includes a tremendous variety of diverse and even contradictory strands of thought. Further, recent critiques fail to acknowledge the evolution of work within the systems tradition that has itself sought to address earlier critiques. The predominant conception of systems thinking within much of the academic community is based on a limited understanding of the whole range of systems thought and fails to recognize the potentially progressive and liberating implications of some developments within the systems movement.

Many members of the general-systems society were themselves quite disturbed by the applications of systems ideas in government, industry, and the military that were the focus of most critiques. Far from supporting the more hierarchical orientation of the military-industrial approach to systems, these individuals were concerned with developing conceptions of social organization that took into account the highly interdependent nature of contemporary society, while still seeking to preserve the participatory and inclusive ideals of democratic theory. In place of a totalizing vision, they emphasized the importance of a multiplicity of perspectives. Even among the founders of the SGSR there are significant differences in orientation. In discussing their work, I hope to clarify the relationship between the general-systems approach and the more technocratic orientation of such fields as systems engineering, systems analysis, and operations research.

Although the countercultural movement of the 1960s contributed to disillusionment with "the system," aspects of the countercultural perspective, represented in the work of such writers as Gregory Bateson, Fritjof Capra, Hazel Henderson, and Joanna Macy, draw heavily on the more holistic and ecological orientation of certain developments under the umbrella of systems thinking. This countercultural systems orientation is reflected, as well, in the "Gaia hypothesis" of James Lovelock and in the emergence of "deep" ecological perspectives, which highlight the self-organizing and yet interdependent nature of living systems.[16]

The founders of the SGSR occupy a sort of intermediary position between the highly technocratic application of systems ideas and the countercultural view. From my perspective as a not entirely disinterested scholar, it seemed that they were primarily concerned with understanding the organizational and decisionmaking processes in human society in order to make them more responsive to human needs and not simply to manipulate or control them. My purpose, then, is to reconsider the contributions of this tradition, to clarify its fundamental assumptions and values, and to distinguish aspects that are unique to this group and set it apart from other parallel developments in systems thinking.

HISTORICAL ROOTS OF SYSTEMS THINKING

C. West Churchman, who first introduced me to the general-systems community, was a longtime member and former president of the SGSR and has written extensively on the topic of systems thinking. His own professional evolution is typical of the intellectual richness of the tradition. He describes himself as an intellectual grandson of William James, having studied philosophy with a student of James's by the name of E. A. Singer. During World War II, he was actively involved with the development of operations research, going on to spend much of his professional career teaching in the School of Business at the University of California at Berkeley. After retirement (and into his early eighties), he continued to work in the Peace and Conflict Studies Program, teaching courses on ethics.[17]

In conversations with Churchman on the historical sources of systems thinking, he often identified the Chinese *I Ching* as the oldest systems approach. As an effort to model dynamic processes of changing relationships between different kinds of elements, the *I Ching* might be seen as a *systemic* approach, in contrast with the more *systematic* approach of rationalist Western thought, rooted in the work of Plato and Aristotle. The pre-Socratic philosophers were perhaps closer in spirit to the Eastern view than they were to the more orderly view of systems embodied in the later evolution of the Western tradition. This is particularly true of Heraclitus, whose inspiration is often cited in connection with the more progressive developments within the contemporary systems tradition. This contrast between systemic conceptions, which focus on interrelationships and dynamic processes, and the systematic conceptions, which are more concerned with classification and order, is critical in understanding the relationship between different views of systems in the twentieth century.

Plato's *Republic* anticipates attempts at rational planning and "social engineering" of society that are frequently associated with the systems approach. In his critique of the systems approach, Lilienfeld refers to the technocratic social engineers as "scientist-kings." Michael Ghiselin, writing in 1974, suggests that the *Republic,* along with Aristotle's *Politics,* embodied an organismic conception of society, a central conception in some systems views, which is further developed in the early schools of sociology. For Ghiselin, the organismic (or holistic) view is inherently teleological (or purposive), reflected in the Aristotelian notion of final cause. By positing the whole as primary, "that for the sake of which" individuals exist and by which they are determined, adopting a "downward" conception of causality, holism imputes purposiveness into the world, something inadmissible in contemporary science. As a self-confessed radical individualist and rigorous neo-Darwinian, Ghiselin rejects such a view, reflecting a perspective fairly common among biologists, although this is changing with the recent emergence of such fields as developmental systems. And of course, progressive social theorists also reject the concept of "downward causation," associated with holistic and organismic models, as subordinating the interests of the individual to that of the collective.[18]

For Ghiselin, holism is equivalent to the Leibnizian notion that we live in "the best of all possible worlds," reflecting the common complaint among sociologists that systems approaches tend to reinforce the status quo. Leibniz is, in fact, often referred to as an important precursor of systems theory in his notions of "living machines" and "living automata" and in his quest for a universal mathematics. Peter Galison discusses the significance of Leibniz's theory of monads in connection with the development of cybernetics. Some aspects of the systems view might also be seen as an extension of the *esprit de système* associated with Descartes's mathematical rationalism. At any rate, systems theories can be seen as rooted in two distinct developments: some that have attempted to reintegrate a more holistic perspective and others that have grown out of the quantifying spirit, nurtured in the scientific revolution of the seventeenth century and further developed in the ensuing century of the Enlightment, or the Age of Reason. Within both the holistic and the rational traditions, there are respective branches fostering either static or dynamic interpretations, resulting perhaps in either repressive or liberating consequences for humanity, although the distinctions are not always so clear.[19]

Looking at more recent philosophical traditions, systems thinking has drawn variously from positivism, pragmatism, Hegelian dialectics (with its emphasis on dynamic processes of change), and the organismic holism reflected in the work of Alfred North Whitehead and Jan Christiaan Smuts. Bertalanffy grew up in the Vienna of the logical positivists, and was a student of Moritz Schlick, through whom he was introduced to the "Vienna Circle." Although he rejected what he saw as the reductionism of their conception of positivism, Bertalanffy was sympathetic to their ideal of a unified science, elaborating his own organismic approach based on his work in developmental biology. As the only member of the group trained in the social sciences, Boulding drew on the pragmatist tradition, acknowledging George Herbert Mead and John Dewey as important precursors to his work on the role of perception in the evolution of social systems.[20]

Part 1 of this study offers a brief overview of specific developments contributing to the evolution of general-systems thought, in the fields of organismic biology and gestalt psychology (Chapter 2), engineering and management (Chapter 3), cybernetics and information theory (Chapter 4), and ecology and social theory (Chapter 5). Systems ideas emerge out of a complex synthesis of developments in what might seem to be relatively unrelated fields. My own introduction to the systems field was in connection with research on theoretical orientations in biology. I had not realized the extent to which developments in technology and management were central to the evolution of systems ideas, and in fact I shared my generation's general distrust of these fields. Perhaps the dominant strand of systems *analysis,* as distinguished from systems *theory,* can be seen as a progression from systems engineering, which deals primarily with technological systems, to management science and organizational theory, which deal with the dynamics of complex technological systems that include human individuals and social organizations. The evolution of organizational theory then overlaps with contemporary developments in social theory, which are similarly influenced by ideas from cybernetics and information theory during this period. The development of cybernetics, in turn, was rooted in biological discoveries relating to organization and the maintenance of steady states in living organisms through the process of homeostasis.[21]

The second chapter describes these developments in the field of biology, which were central in shaping my own initial understanding of systems, as well as that of the five founding members of SGSR. Bertalanffy's conception of organismic biology, with its roots in the examination of developmental processes, provides an important starting point for his elaboration of GST. Miller's research on living systems was significantly influenced by his association with Walter Cannon and Lawrence Henderson at Harvard and their work on self-regulating mechanisms in living organisms, which was also influential in the evolution of Talcott Parsons's social-systems theory. Organismic models in both ecology and social thought were equally important in the development of systems concepts. The holistic orientation of these fields during this period is also reflected in the emergence of gestalt psychology, a major impetus in the development of the behavioral-science field as well. Further developments in biological systems thinking, in the rational (or quantitative) tradition, came with the mathematical analysis of population. Most significant in this field was the work of Alfred Lotka and Vito Volterra, who developed equations for representing predator/prey relationships, which had a significant impact on the evolution of Bertalanffy's thinking and also informed Nicholas Rashevsky's work in mathematical biology at the University of Chicago, in turn shaping the development of Rapoport's conception of GST.[22]

Chapter 3 outlines the significant influences that came out of engineering, particularly in connection with the development of complex technological systems including transportation, communication, and energy networks, as well as the organizational skills that were necessary to implement and manage these systems. J. Willard Gibbs's work on thermodynamics had a profound impact on the early evolution of systems thought, shaping early conceptions of systems in biology and sociology. More significant, in connection with my own concerns, is the way in which engineering models formed the foundation for management theory, beginning with the time and motion studies that characterized Frederick Taylor's "scientific" approach to management. Perhaps even more important were military developments during World War II, which required far more sophisticated coordination of increasingly complex technologies, ushering in such fields as operations research, systems analysis, and game theory. All of these developments highlight the critical role of the decisionmaking process in the establishment and maintenance of social organization, a central focus in Boulding's work and in my own understanding of the significance of systems ideas.

The emergence of the fields of cybernetics and information theory is described in Chapter 4. Cybernetics drew its inspiration from ideas about feedback and homeostasis in Cannon's work on self-regulation in living systems, as well as from engineering developments in connection with self-correcting weapons systems. Equally important was Leo Szilard's 1929 paper discussing the difference between matter/energy and information that might be seen as ushering in the information era. Claude Shannon and Warren Weaver's book, *The Mathematical Theory of Communication* (1949) was second only to Norbert Wiener's *Cybernetics* (1948) in shaping the evolution of systems thinking. And the growing concern with information and communication can be seen in the evolution of functionalist thought in social theory, as well as in more recent currents of literary criticism and deconstruction.[23]

While the cybernetic idea of feedback is not the only principle of interest to the general-systems theorists, it provides the most important conceptual breakthrough in understanding interrelationships between different components of complex systems, as well as an alternative to the linear causal models of traditional mechanistic science, incorporating an appreciation for mutual causality and the self-reinforcing patterns of trial and error that can account for learning and development. To some extent, cybernetics and related developments in information theory and technology emerged from the extension of mechanistic models, while Bertalanffy's conception of GST arose out of a holistic and antimechanistic impulse. Although the further evolution of GST drew extensively from cybernetics and information theory, reflected in the overlapping memberships of the Society for General Systems Research and the American Society for Cybernetics, both Bertalanffy and Boulding tended to distinguish between what they saw as the evolutionary and developmental orientation of the general-systems approach—highlighting the importance of learning and reflexivity—and what they saw as an orientation toward control reflected in the emphasis on equilibrium in the cybernetics approach.[24]

This tension between control and self-organization becomes even more pronounced in Chapter 5, which explores the roots and the influences of systems thinking in both ecology and social thought. Systems concepts in ecology and social theory are explored together, as both fields examine interactions between individual organisms and their environment, a focus that Darwin's theory of natural selection served to reinforce. The first part of the chapter traces the emergence of ecology as a new discipline in the twentieth century: the evolution from organismic to systemic models, the emergence of economic metaphors and mathematical modeling (including feedback models), the proliferation of different schools such as population ecology and ecosystem ecology, and the gradual transition away from any consideration of the relationship between the human community and the natural environment.

Theoretical frameworks in social thought reflect a similar evolution, in the transition from Spencer's organismic model to Parson's social-systems theory, for example. The second section of the chapter provides a brief schematic overview of different trends in social thought, focusing specifically on the tension between functionalist and interpretive schools of thought. The tension between these two perspectives highlights the relationship between objective and subjective dimension of human experience. In the interpretive view the role of perception, values, and motivation becomes much more significant.

The new field of social psychology, also central in the development of the behavioral sciences, sought to understand the social factors shaping individual human behavior. Kurt Lewin's work in field theory was particularly influential in this regard. Social psychology generally built upon an open-system model for examining human behavior, viewing humans as purposive, interdependent with the physical and social environment, and actively involved in transactions with that environment as they pursue their goals. In this model, individuals require the mental capacity for deciding, as well as an appreciation for the role of belief systems and information in shaping their decisions. The decisionmaking process thus becomes a critical area of analysis.

DEFINING THE GENERAL-SYSTEMS APPROACH

The SGSR was one of several efforts to synthesize these diverse strands of systems thought. Perhaps the most distinctive characteristic of the general-systems group was its focus on articulating common principles that would apply to many different kinds of systems. Russell Ackoff, whose interest in GST evolved out of his work in operations research and management theory, identifies three kinds of systems—technological, biological, and social. Bertalanffy's initial conception of the range of systems to be considered was even broader, including natural physical systems as well as psychological and symbolic systems. Within the general-systems community, there are different views as to the "reality" of these systems. James Miller emphasizes his concern with concrete systems, which can be identified and described, rather than abstract systems, which have no basis in the real world. Raul Espejo, on the other hand, argues that systems are only mental constructs that can help in understanding complex patterns of interrelationships, but cannot reflect the actual world.[25]

In formal mathematical terms, a system can be defined as a set of differential equations that describe the relationships between different variables, which can be solved in order to maximize or minimize particular values. This process forms the basis for much of the early work in operations research and management science, with the help of computers that were capable of solving the complex sets of equations involved in such cost-benefit analyses. The ethical problems with this approach are obvious, although it was often very effective in achieving its ends. With the evolution of computer technology beyond the purely computational mode, however, techniques of mathematical modeling and simulation of complex systems have paved the way for dramatic developments in chaos and complexity theories that have begun to challenge the old managerial ethos.[26]

Although some critics have objected to the use of a single term to cover so many diverse kinds of entities, a system can be defined in general terms as a set of relationships between discrete things that together form some kind of coherent pattern and/or whole that is capable of maintaining itself through time. For the general-systems community, the concept implied a concern with the relationship between a system and its environment, where system and environment can be defined differently depending upon the level of the phenomenon under consideration, resulting in a nested, or "holonic," model where every entity can be seen as either system or environment, depending on one's perspective. Another key element of the general-systems view is the open nature of living systems, raising the question of how such systems maintain their identity and preserve some aspect of self. Such a question highlights the tension between the maintenance of order and stability in a system and the potential for evolution and change, a central theme throughout this study.[27]

In discussing the evolution of systems thinking, Kramer and Smit point out that there is "no generally accepted, clearly defined body of knowledge concerning systems thinking," and they suggest that the multiplicity of systems approaches is reflected in the variety of terms, including systems theory, systems thinking, systems approach, systems analysis, systems synthesis, systems engineering, etc. These terms refer to various fields of knowledge that sometimes overlap and are often very much at odds. In addition, such terms are often used indiscriminately by systems thinkers themselves.[28]

There are, however, some commonalities between the various systems approaches. They have all emerged in conjunction with attempts to solve the increasingly complex problems of industrial society. Systems concepts evolved out of parallel efforts in a variety of fields to facilitate the kind of interdisciplinary communication that was necessary to address the multidimensional aspects of such "messy" problems. In the process, ideas from engineering were applied in biology and social theory, while developments in biology, particularly concepts of feedback and homeostasis, in turn influenced developments in engineering. The various systems approaches are all rooted in two fundamental premises: (1) reality is seen in terms of wholes, and (2) the environment is seen as an essential component. Expanding on this definition, Peter Checkland writes that the systems view "assumes that the world contains structured wholes which can maintain their identity under a certain range of conditions," and cites Russell Ackoff, who wrote in 1974 that we are living in "The Systems Age."[29]

THE FOUNDERS OF THE SOCIETY FOR GENERAL SYSTEMS RESEARCH

Ludwig von Bertalanffy is generally considered the father of general systems theory and his work is addressed in depth in Chapter 6. The concept of the open system, inspired by his work in developmental biology, is his most important contribution to the field. Essentially, it is based on the argument that living organisms cannot be understood as equilibrium systems. Instead, they are capable of maintaining themselves in a continual nonequilibrium state and maintaining complex levels of organization by importing matter and energy from the environment and exporting their entropy or waste. While he did not speak in terms of the "spontaneous emergence of order" characteristic of more recent developments in chaos theory, similar insights are reflected in his emphasis on the autonomy, creativity, and spontaneity of living organisms, and the progressive emergence of increasingly complex self-organizing systems.

Having been influenced in his early years by the Vienna Circle, Bertalanffy later rejected the reductionism of their approach, although he shared their dream of the unification of knowledge. Although Bertalanffy initially conceived GST in mathematical terms, much of his writing reflects a deeper concern with the mechanistic and reductionist orientation of then-current models in biology and psychology. The most significant influences in the evolution of his own thinking were philosophers and mystics, including Heraclitus, Nicholas of Cusa, and Leibniz. In parallel with the Theoretical Biology Group in England, he worked to develop an organismic conception of life that would address what he saw as the limitations of the mechanistic view without appealing to the supernatural forces of vitalism. His holistic and antimechanistic orientation can be seen in his attraction to the gestalt school of psychology and his vehement rejection of the stimulus-response model in behaviorist psychology. For Bertalanffy, the behaviorist conception of the organism as entirely passive contributed to a view of humanity that justified totalitarian forms of social control. In contrast, he emphasized the active and self-organizing character of human behavior.

As the field evolved, Bertalanffy described GST as a humanistic approach in contrast to the more dehumanizing orientation of many of the technological and managerial applications of systems models. He distinguished between the more radical implications of systems *philosophy,* which entailed a rethinking of traditional conceptions of ontology and epistemology, and the applications of systems *technology,* which were primarily geared to solving practical organizational problems of modern industrial society, without reexamining its fundamental assumptions. He hoped to challenge the limitations he saw in the linear causality and mechanistic orientation of classical science. From my own perspective, the most interesting aspects of his work are his critique of mechanistic and reductionist approaches in science and his emphasis on the importance of multiple perspectives, which are often ignored in critiques of his work.

Chapter 7 explores the collaborative work of Gerard, Miller, and Rapoport on the newly established Behavioral Science Committee at the University of Chicago in the early 1950s, and later at the Mental Health Research Institute at the University of Michigan. Although Miller wasn't one of the initial four who articulated the vision of SGSR at the CASBS lunch table, he was closely connected with Gerard and Rapoport and his work was central to the development of the society.[30]

Although his training was in the field of neurophysiology, Gerard was closely associated with the community of ecologists at the University of Chicago. The "Chicago School" of ecology emphasized the importance of community and cooperation in its studies of animal behavior, a central aspect of Gerard's organismic view of society. He was also a participant in the Macy conferences on cybernetics in the 1940s and 1950s. The range of his interests was quite broad. He was often asked to give summary comments at conferences, and he wrote extensively on topics relating to the role of science in society. Of the original founders, his orientation toward the behavioral sciences reflects the strongest tendency toward social control. At the same time, he was also the least involved with the society as it evolved.[31]

Miller, on the other hand, was very active in the society and regularly attended the annual conferences. As he writes in his introduction to *Living Systems,* his work was profoundly influenced by Alfred North Whitehead at Harvard. Equally significant was the work of biologists Walter Cannon and Lawrence Henderson, also at Harvard, on the physiology of homeostasis. Both Whitehead and later Enrico Fermi at the University of Chicago encouraged Miller to try to integrate concepts in the biological and social sciences. As a psychiatrist, in the developmental years of the field, he had a solid background in both areas. He was hired as chair of the Psychology Department at Chicago in 1948, and began working toward the establishment of an interdisciplinary institute in the behavioral sciences.

Rapoport was primarily interested in the application of mathematical models to the understanding of biological and sociological processes. His participation in Nicholas Rashevsky's Committee on Mathematical Biology, also at Chicago, was probably the most important influence in the development of his thinking. He applied Warren McCulloch and Walter Pitt's model of neural networks to other phenomena such as the spread of disease or the spread of rumors in populations. He was interested in semantics and the symbolic dimension of human behavior, which he thought had to be understood in structural rather than analytic terms. Both he and Boulding were very active in the newly emerging field of peace research, which also grew out of associations formed at the CASBS, based on the work of Lewis Richardson, who had developed mathematical models of conflict situations. Rapoport's work in game theory reflects this focus, challenging the more militaristic conclusions of the government-funded think tanks during the 1960s and 1970s in his articulation of non–zero-sum models of interaction.

The Committee on the Behavioral Sciences began meeting under Miller's leadership in 1952 and continued until around 1967, with Gerard, Miller, and Rapoport as the most consistent members of the group. The committee reflected widespread efforts to develop integrated approaches to the study of human behavior, which were accelerated in the climate of the Cold War. The University of Chicago was one of the most important centers for interdisciplinary research in the social sciences, and the behavioral-science group was very influential in the formulation of the Ford Foundation's program for CASBS. Gerard and Rapoport continued to meet during their year at CASBS, with Miller joining them whenever he could. He had procured funding from the state of Michigan to establish the Mental Health Research Institute at the University of Michigan, which was to become the institutional headquarters of the general-systems society, drawing a number of researchers from Chicago and CASBS, including both Gerard and Rapoport.

An analysis of Boulding's critical role in the evolution of general-systems thinking, and as the real hero of my tale, concludes this section in Chapter 8. While Bertalanffy is acknowledged as the father of general systems theory, Boulding was instrumental in initiating the establishment of the society and was actually responsible for bringing Bertalanffy to CASBS during that first year. Boulding is the only member of the four who was not a biologist, although his thinking was significantly influenced by biological models. He saw every system of interacting populations as an ecosystem, incorporating insights from ecology into his work in economics and social theory, and is recognized today as one of the primary founders of the field of ecological economics. He was also very active in the Quaker community and his interest in systems was integrally connected with his work on peace research. Together with Anatol Rapoport, he established the Center for the Study of Peace Research and Conflict Resolution at the University of Michigan.

The most important influence in Boulding's conception of general systems theory was the series of interdisciplinary seminars that he taught at the University of Michigan beginning in 1950. Reflecting dominant themes of the postwar era, the first seminar addressed a variety of perspectives on competition and cooperation. The second focused on the elaboration of a theory of the individual, leading to the development of Boulding's taxonomy of different kinds of systems based on levels of complexity. In the third seminar, he sought to articulate a theory of growth, in the context of which he was first introduced to Bertalanffy's ideas. The fourth seminar addressed the theme of information and the fifth dealt with conflict. One of his most important contributions to the general-systems view was his concept of the *image,* a perceptual framework that is both cultural and evolutionary, which inspired his ongoing concern with the role of perception and values in the decisionmaking process.

EVALUATING THE HERITAGE OF GENERAL-SYSTEMS THOUGHT

The last section of the book provides a brief summary of the activities and contributions of the SGSR as it evolved during its first few decades (Chapter 9) and explores their significance in relation to my own motivating questions (Epilogue). The society nurtured a number of diverse areas of interest within the general-systems community, creating various task forces, educational programs, annual conferences, and institutional centers that emerged in connection with its evolution. Articles contributing to the elaboration of the general-systems perspective were published in the annual yearbooks, edited primarily by Rapoport. In general, the concerns and orientations of the general-systems group cover a substantially broader range than most other systems-oriented traditions and institutions, which some felt might have contributed to a decline in membership in later years, while others believed that the relative openness of the group fostered innovations that might not find a place in more narrowly conscribed organizations.

Despite the relative openness, there are several areas of tension that emerge within the society, to some extent reflecting disciplinary commitments, in an ongoing evolution of C. P. Snow's *Two Cultures*. From the perspective of my own question, the most significant tensions seemed to lie along the polarities outlined in Table 1.1. Of course there are others ways of viewing the tensions. Some define the contrast in terms of closed and open systems. There are tensions between instrumental and values-based orientations, and between holistic, ecological, and mechanistic perspectives. Boulding distinguished between "special" general systems, reflected in the more quantitative approaches to modeling systems, and "general" general systems, reflecting a broader philosophical inquiry into the overall dynamics of social, biological, and technological systems that embraces concerns with values and meaning. Perhaps most significantly, there is the tension between seeking to understand the world and seeking to change it.[32]

Although the stated aims of the society were initially theoretical, to foster research into formal similarities between different levels of organization, over time its members became increasingly concerned with practical applications in policy and management, as well as with efforts toward social change. The society has

Table 1.1. Contrasting Views on the Social Implications of Systems Theory

Self-Organization	Externally Imposed Order and Control
Free Will, Creativity, Spontaneity	Determinism
Participatory Decisionmaking	Hierarchical Decisionmaking
Democracy	Technocracy

struggled to integrate the technological and social dimensions of systems thinking, often distinguished as "hard" and "soft" systems approaches, and is unique in attempting to bridge these diverse fields and find some common ground.

During the 1970s the SGSR became closely associated with the American Society for Cybernetics (ASC), which grew out of the initial conferences on cybernetics sponsored by the Macy Foundation and, in later years, tended to focus less on the technological aspects of cybernetics, and more on the role of self-reflexivity in the evolution of purposeful behavior, in what Heinz von Foerster named "second-order cybernetics." The SGSR has some affinity, although fewer direct connections, with the system dynamics group that was rooted in Jay Forrester's work on urban dynamics at the Massachusetts Institute of Technology. Forrester's work drew on his background in control engineering, using computers to model feedback processes in complex social and industrial systems, and provided the foundation for *The Limits to Growth* (Meadows et al., 1972), an influential critique of exponential growth sponsored by the Club of Rome, as well as the more recent work of Peter Senge (1990) on the concept of the learning organization.[33]

The SGSR also had some connections with such organizations as the RAND Corporation and the International Institute for Applied Systems Analysis in Austria, which was modeled after RAND, although both of these organizations tended to involve a more limited focus on traditional systems analysis as well as more direct affiliations with government and industry. Table 1.2 reflects my attempt to categorize some of the developments within the very broad conceptual framework of systems thinking. The general-systems, cybernetics, and system-dynamics groups tended to incorporate more critical and ethical dimensions in their work. Although some developments within the system tradition clearly lent themselves to projects in social engineering, a number of thinkers within these three groups sought to address critical questions about the processes involved in the design and planning of social institutions.

In the Epilogue, I offer my reflections on the significance of the general-systems approach in the context of contemporary developments in social thought and practice. The general-systems group made important contributions to contemporary understanding in a number of areas that have generally been unrecognized or misunderstood. Recent work in this tradition offers unique and important insights, particularly in the areas of organizational theory and practice. The tension between hard- and soft-systems approaches is clearly a central issue, closely related to my own motivating question as to whether the general-systems view tends to support hierarchical organization and social control or more participatory and inclusive forms of social organization. There has been substantial work addressing issues of conflict, power, and the role of the systems theorist within the systems community, and a 1995 conference of the United Kingdom Systems Society addressed the question of whether or not an "emancipatory" systems approach might be possible.

Members of the SGSR have been particularly concerned with understanding the reasons for the decline of interest in systems theory in recent years. Perhaps most significant is the influence of postmodernism with its distrust of universaliz-

Table 1.2. A Spectrum of Systems Approaches

Problem Solving	*Modeling*	*Synthesis/ Integration*	*Change in Consciousness*
Systems Engineering	System Dynamics	Cybernetics	New Paradigm Thinkers
Systems Analysis	Systems Ecology	General Systems Theory	Deep Ecology
RAND Corporation	Dynamical Systems Chaos/Complexity		

ing frameworks and metanarratives. General systems theory might appear to be the ultimate metanarrative, yet many of the general-systems theorists bridged modern and postmodern frameworks, anticipating some of the recent development in social theory, particularly in their analysis of the social construction of knowledge. Central to this project were epistemological considerations growing out of cybernetic and neurophysiological insights into the self-reflexive nature of perception, the "second-order cybernetics," which focused on the process of observation and the relationship between the observer and the observed.

The concept of self-organization, which is fundamental to general-systems thought, emerged initially out of theoretical work in developmental biology and provides a biological framework for understanding social organization that might support participatory and inclusive forms of social organization, unlike the earlier organismic models that tended to promote social control. In contrast to the classical mechanistic view, which tends to reinforce a deterministic understanding of human behavior, many in the general-systems group emphasize the importance of creativity and spontaneity, encouraging individuals to take a more active part in the process of determining their own reality.[34]

Although he acknowledges the potentially destructive aspects of technology in homogenizing human culture and disrupting the international community of nations, Daniel Boorstin describes the United States in glowing terms as "the most technologically advanced great nation in the late twentieth century" and "a center from which radiate the forces that unify human experience." Despite barriers, he argues that "the converging powers of technology will eventually triumph." Such technocratic optimism is generally considered to be part and parcel of the systems view. West Churchman also describes the systems approach as essentially optimistic about the potential for coordinating complex human and technological systems, although his conception of the systems approach is grounded in ethical considerations and recognizes the systems analyst or observer as an integral part of the system.[35]

Christopher Lasch suggests that progressive optimism rests on "a denial of the natural limits on human power and freedom, and it cannot survive for very long in a world in which an awareness of those limits has become inescapable." Related to this growing awareness is an understanding of the essentially political nature of the scientific and technological enterprise, as scientists are being forced into a greater awareness of their relations with the power system in society. In parallel with the technocratic vision, another more critical perspective emerged, highlighting the potential for technology to be used as an instrument for control and domination. Beginning with Max Weber and including such writers as Lewis Mumford, Jacques Ellul, and the critical theorists of the Frankfurt School, the inexorable advance of technology and the bureaucratic mentality is seen to be generating "a paralyzing web of instrumentality" and enslaving modern man. By emphasizing technology and embracing the "myth of the machine," contemporary Western culture has neglected important aspects of human life.[36]

The instrumental mentality, often seen as the essence of modernity, is described by David Harvey as positivistic, technocratic, and rationalistic, embodying such values as "absolute truth, rational planning of ideal social orders, and standardization of knowledge and production." The systems view tends to be seen as the apotheosis of modernity. On the other hand, the general-system group reflects facets of the postmodern perspective in its concern with pluralism and its appreciation for the social construction of knowledge. Furthermore, a number of contemporary systems theorists have drawn heavily from critical theorist Jurgen Habermas's analysis of the instrumental rationality of the "systems world" and its subordination of the subjective experience of the "life world."[37]

Postmodern perspectives emphasize the ultimate irreconcilability of heterogeneity and difference, and tend to see liberation only "outside of the system," much as the generation of the 1960s thought that the only possibility for creative change was outside the system. In contrast, members of the general-systems community tend to see the interactions between diverse components of the social system as potentially coherent, without having to be constrained or controlled. And in fact, as many in the countercultural generation have discovered, there is ultimately no place that is truly outside of the system. This is most beautifully articulated in the work of the Vietnamese Buddhist monk Thich Nhat Hanh, who explains how, if one looks carefully at a piece of paper, one can see the sun and the water that nurtured the growth of the tree, as well as the logger who cut it down and all of the processes involved in the production and distribution of the paper. Echoing the perspective of deep ecology, he suggests that there is nothing that does not have a connection to that piece of paper. Similarly, despite our efforts to maintain the illusion of separate existence, there is ultimately nothing that is truly "outside" of the system.[38]

In his analysis of the postmodern spirit, Harvey suggests that the city, as the ultimate achievement of modernity, is "not falling victim to the totalitarianism of planners, bureaucrats, and corporate elites" (although these days they seem to be making some heroic efforts in that direction). It is rather, he argues, "much too complicated a place ever to be so disciplined." On the other hand, it is in the cities that we are witnessing the ultimate breakdown of both the human community and the natural environment, a situation that systems theorists might describe as a bifurcation point, with the potential for either further disintegration or the emergence of a more equitable and sustainable form of social organization. This possibility for self-transcendence within the system is critical for an understanding of the potentially liberating aspects of systems *theory*.[39]

NOTES

1. From Arnold Thackray, "CASBS: Notes Toward a History," *CASBS Annual Report* (1984), p. 63.

2. From Kenneth Boulding Collection in the University Archives at the University of Colorado in Boulder, hereafter referred to as KEB/CU, in a file entitled "Unpublished Verse."

3. See Thackray, "CASBS: Notes Toward a History," pp. 59–71, for a good summary of the Ford Foundation's planning process for the center; also "Appendix: Historical Note on the Development of the Center" (in Kenneth E. Boulding Collection at the Bentley Historical Library at the University of Michigan in Ann Arbor, hereafter referred to as KEB/MI, Box 5, Correspondence, Sept. 1954), pp. 2–4.

4. See Peter Taylor, "Technocratic Optimism, H. T. Odum, and the Partial Transformation of Ecological Metaphor After World War II," *Journal of the History of Biology* 21:2 (summer 1988), for a comparison of the behavioral sciences with the Manhattan Project.

5. See Steve Heims, *Constructing a Social Science for Postwar America: The Cybernetics Group, 1946–1953* (Cambridge, MA: MIT Press, 1991), for a discussion of the enlistment of social scientists in efforts to contain communism. As he notes, the link between government and intellectuals was much greater during this period than it is today.

6. I am indebted to James Miller for pointing out the political significance of the behavioral-science concept. See also Ralph Tyler, "Institutional Organization of the Behavioral Sciences," in Bernard Berelson, ed., *The Behavioral Sciences Today* (New York: Basic Books, 1963), p. 12. Corporate contributions were directly primarily toward research related to personnel and consumer behavior.

7. James D. Thompson and Donald R. Van Houten, *The Behavioral Sciences: An Interpretation* (Reading, MA: Addison-Wesley, 1970), pp. viii, xi, 3–5.

8. Richard Jessor, "Behavioral Science: An Emerging Paradigm for Social Inquiry," in *Perspectives on Behavioral Science: The Colorado Lectures* (Boulder, CO: Westview Press, 1991), p. 314.

9. See Tyler, "Institutional Organization," pp. 18–20, 23.

10. Leonard D. White, *The State of the Social Sciences* (Chicago: University of Chicago Press, 1956), pp. 1–4.

11. See eight problem areas articulated by the Ford Foundation's Behavioral Science Division in Thackray, "CASBS: Notes Toward a History."

12. David Hollinger, "Academic Culture at Michigan, 1938–1988: The Apotheosis of Pluralism," *Rackham Reports* (1989): 64. See also Dorothy Ross, *The Origins of American Social Science* (Cambridge: Cambridge University Press, 1991), pp. 457, 472–473, for a discussion of the quantitative orientation of the behavioral sciences. She discusses the extension and elevation of scientism in the work of Harold Lasswell, whom she describes as the father of the behavioral movement in political science in the 1950s.

13. While the story is often repeated that the idea for SGSR was hatched at CASBS, Boulding and Bertalanffy had already exchanged correspondence discussing the possibility of forming a society to study general systems theory prior to the opening of the center. They had also sent out letters soliciting interest in such a venture, receiving an enthusiastic response from Rapoport among others (see Chapter 9 for further discussion).

14. George Klir, "Preview: The Polyphonic GST," in George Klir, ed., *Trends in General Systems Theory* (New York: Wiley, 1972), pp. 1, 16.

15. Robert Lilienfeld, *The Rise of Systems Theory: An Ideological Analysis* (New York: Wiley, 1978). See also Ida Hoos, *Systems Analysis in Public Policy: A Critique* (Berkeley: University of California Press, 1972); Donna Haraway, *Simians, Cyborgs, and Women: The Reinvention of Nature* (New York: Routledge, 1991), especially chapters 3 and 9; Taylor, "Technocratic Optimism"; Ross, *American Social Science,* p. 456; and Jean-François Lyotard, "From the Postmodern Condition: A Report on Knowledge," in David Ingram and Julia Simon-Ingram, eds., *Critical Theory: The Essential Readings* (New York: Paragon, 1992).

16. See, for example, Gregory Bateson, *Steps to an Ecology of Mind* (New York: Ballantine Books, 1972); Fritjof Capra, *The Turning Point* (New York: Simon and Schuster, 1982); Lawrence Henderson, *Paradigms in Process* (Indianapolis: Knowledge Systems Inc., 1991); and Joanna Macy, *Mutual Causality in Buddhism and General Systems Theory* (Albany: State University of New York Press, 1991). On the Gaia hypothesis, see James Lovelock, *Gaia: A New Look at Life on Earth* (Oxford: Oxford University Press, 1982); and on deep ecology, Freya Mathews, *The Ecological Self* (Savage, MD: Barnes and Noble, 1991). See also Carolyn Merchant, *Radical Ecology: The Search for a Livable World* (New York: Routledge, 1992); and Carolyn Merchant, ed., *Ecology: Key Concepts in Critical Theory* (Atlantic Highlands, NJ: Humanities Press, 1994); and Edward Goldsmith, *The Way: An Ecological World View* (Boston: Shambhala, 1993).

17. See C. West Churchman, *The Design of Inquiring Systems* (1971), *The Systems Approach* (1979), and *The Systems Approach and Its Enemies* (1979). He was the primary author, with Russell Ackoff and Leonard Arnoff, of *Introduction to Operations Research* (1957), one of the first textbooks in the new field.

18. Lilienfeld, *The Rise of Systems Theory;* Michael Ghiselin, *The Economy of Nature and the Evolution of Sex* (Berkeley: University of California Press, 1974), pp. 9–12. The reemergence of systems concepts in biology can also be seen in a recent issue of *Science* (vol. 295, March 1, 2002), which featured a series of articles on systems biology.

19. Peter Galison, "The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision," *Critical Inquiry* 21 (autumn 1994): 255; Jessica Riskin, "From Electricity to Economy: Enlightenment Debates in Natural and Political Philosophy" (unpublished paper addressing the Cartesian "spirit of systems"). George Richardson traces the notions of living machines and living automata to Leibniz's "Monadology" (1714), in *Feedback Thought in Social Science and Systems Theory* (Philadelphia: University of Pennsylvania Press, 1991), p. 64.

20. See Alfred North Whitehead, *Science and the Modern World* (New York: Macmillan, 1925); and Jan Christiaan Smuts, *Holism and Evolution* (New York: MacMillan, 1926).

21. The field of dynamical systems theory, which is not addressed in this study, deals with complex mathematical systems and laid the groundwork for contemporary developments in chaos and complexity theories, which have recently begun to shape developments in technology and management, as well as in biology, ecology, and social theory.

22. See Richardson, *Feedback Thought,* p. 49; and Thompson and Van Houten, *The Behavioral Sciences,* p. 13.

23. Norbert Wiener, *Cybernetics: Or Control and Communication in the Animal and the Machine* (Cambridge, MA: MIT Press, 1948); also *Human Use of Human Beings: Cybernetics and Society* (New York: Avon Books, 1967/1950), p. 27; Nic J.T.A. Kramer and Jacob de Smit, *Systems Thinking: Concepts and Notions* (Leiden, Netherlands: Martinus Nijhoff, 1977), p. 4. Kramer and Smit suggest that Leo Szilard was in the forefront with his observations on the relationship of information to the concept of entropy, in "Über die Entropieverminderung in einem thermodynamischen System bei Eingriffen intelligenter

Wesen," *Zeitschrift fur Physik* 53 (1929). See J. Willard Gibbs, *Elementary Principles in Statistical Mechanics, Developed with Especial Reference to the Rational Foundation of Thermodynamics* (New York: C. Scribner's Sons, 1902). See also Galison, "Ontology of the Enemy," for a discussion of the impact of Wiener's work on Jean-François Lyotard's conception of language and communication in *The Postmodern Condition,* trans. Geoff Bennington and Brian Massumi (Minneapolis: University of Minnesota Press, 1984).

24. Bertalanffy was in Austria during the early development of cybernetics in the United States and was not part of that conversation, which may perhaps account for his insistence on the uniqueness of his own approach.

25. See Raul Espejo, "What Is Systemic Thinking?" *System Dynamics Review* 10:2–3 (summer/fall 1994): 199–212. George Klir, whose work in the systems field has tended more toward the "hard," quantitative approach, has identified five epistemological categories of systems, in more technical terms: (1) the experimental frame, or source system; (2) the given activity of variables; (3) the behavior system; (4) the state transitory system; and (5) the structure system. From *Applied General Systems Research: Recent Developments and Trends* (New York: Plenum Press, 1978).

26. See Hoos, *Systems Analysis,* p. 22, for an example of a mathematical definition of a system; and Margaret Wheatley, *Leadership and the New Science* (San Francisco: Berrett-Koehler, 1992), for a discussion of the implications of quantum mechanics, chaos theory, and self-organization theory for management.

27. Arthur Koestler coined the term "holon" to describe the nested nature of systems, each holon containing within itself smaller holons while also being part of a larger holon (*The Ghost in the Machine* [New York: Macmillan, 1968]). In *Systems Analysis,* Hoos disapproves of the looseness of the word "system" and "the convergence of multiplicity of diverse disciplines and intellectual streams that have somehow been rendered congenial through semantic similitude." Pointing out a variety of meanings for the term "system," including concepts of interaction, interdependence, integral wholes, set of ideas, theory as opposed to practice, structure, and "the combination of a political machine with big financial or industrial interests for the purpose of corruptly influencing a government," she argues that the "common emphasis on wholes serves to maintain a superficial but spurious impression of epistemological universality and consensus" (pp. 15–17, 27).

28. Kramer and Smit, *Systems Thinking,* p. v.

29. Ibid., pp. 1, 5–6; Peter Checkland, *Systems Thinking, Systems Practice* (New York: Wiley, 1981), pp. 6–7.

30. Miller is listed, along with Margaret Mead, as one of the founders of the society in *General Systems,* the yearbook of SGSR. Mead, however, was not involved in the initial efforts that led to the founding of the society, so her work is not discussed at length, although her involvement in the initial meetings of the society is addressed in Chapter 9. Her contributions to the emergence of cybernetics is discussed at length in Heims, *Constructing a Social Science*.

31. Gregg Mitman's account of the Chicago School of Ecology in *The State of Nature: Ecology, Community, and American Social Thought, 1900–1950* (The University of Chicago Press, 1992) includes an extensive discussion of Gerard's work.

32. See C. P. Snow, *The Two Cultures and the Scientific Revolution* (New York: Cambridge University Press, 1959). Tables 1.1 and 1.2 were originally developed for a plenary address on the history of SGSR. See Debora Hammond, "Exploring the Genealogy of Systems Thinking," *Systems Research and Behavioral Science* 19 (2002).

33. See Von Foerster, ed., *Cybernetics of Cybernetics: The Control of Control and the Communication of Communication* (Urbana: Biological Computer Laboratory, University

of Illinois, 1974); Heims, *Constructing a Social Science,* p. 283; Jay Forrester, *Urban Dynamics* (Cambridge, MA: MIT Press, 1969) and *World Dynamics* (Cambridge, MA: MIT Press, 1971); Donella Meadows et al., *The Limits to Growth* (New York: University Books, 1972); and Peter Senge, *The Fifth Discipline: The Art and Practice of the Learning Organization* (New York: Doubleday, 1990).

34. Niklas Luhmann has incorporated the concept of *autopoiesis* ("self-making"), developed in the work of Humberto Maturana and Francisco Varela, in his conception of general systems theory. While further consideration of his work is beyond the scope of this project, it deserves further study, as do the ongoing debates between Luhmann and Jurgen Habermas on the relative merits of systems theory and critical theory. Significantly, many current members of SGSR/ISSS have drawn heavily from the work of Habermas (see Chapter 9).

35. Daniel Boorstin, *The Republic of Technology: Reflections on Our Future Community* (New York: Harper and Row, 1978), p. xv; C. West Churchman, *The Systems Approach and Its Enemies* (New York: Basic Books, 1979).

36. Christopher Lasch, *The True and Only Heaven: Progress and Its Critics* (New York: Norton, 1991), p. 530. Also Stuart S. Blume, *Toward a Political Sociology of Science* (New York: Free Press, 1974), pp. x, 1; and David Noble, *America by Design: Science, Technology, and the Rise of Corporate Capitalism* (New York: Alfred A. Knopf, 1977), pp. xx–xxii. The Frankfurt School included, most notably, Theodor Adorno, Max Horkheimer, and Herbert Marcuse. See Martin Jay, *The Dialectical Imagination: A History of the Frankfurt School and the Institute of Social Research, 1923–1950* (Boston: Little, Brown, 1973).

37. David Harvey, *The Condition of Postmodernity* (Cambridge, MA: Blackwell, 1989), p. 9. Harvey is drawing on a discussion from *PRECIS* 6 (1987): 7–24. See Jurgen Habermas, *The Philosophical Discourse of Modernity* (Cambridge, MA: MIT Press, 1992).

38. Thich Nhat Hanh, *Being Peace* (Berkeley, CA: Parallax Press, 1987), pp. 45–47. Joanna Macy draws on Buddhist insights in her discussion of the concept of mutual causality causality in connection with both general systems theory and the Buddhist notion of "dependent co-arising" (*Mutual Causality in Buddhism and General Systems Theory* [Albany: State University of New York Press, 1991]).

39. Harvey *The Condition of Postmodernity,* p. 5, in reference to Jonathan Raban's argument in *Soft City* (London: Hamilton, 1974).

PART I
The Sources of Systems Thinking

TWO The Science of Life: Organization in Living Systems

> Are there not general principles of stabilization? May not the devises developed in the animal organism for preserving steady states illustrate methods which are used, or which could be used, elsewhere? Might it not be useful to examine other forms of organization—industrial, domestic or social—in the light of the organization of the body?
>
> —Walter Cannon, *The Wisdom of the Body*[1]

My own introduction to the field of systems thinking came about in connection with my search for a "new paradigm"—an alternative to the mechanistic world view that Fritjof Capra had identified as the source of many of our contemporary problems. At first I had expected to focus on twentieth-century developments in physics, such as relativity theory and quantum mechanics, and their theoretical implications in relation to my own quest for a better world. Margaret Wheatley has actually followed a similar path in her discussion of the implications of quantum mechanics, chaos theory, and concepts of self-organization for the way in which we organize and manage our social institutions. In *Leadership and the New Science,* she suggests that the Newtonian framework for understanding our world has resulted in a focus on control. On the other hand, the flowering of modern science catalyzed by Newton's work is often associated with the emergence of democratic social movements in the eighteenth century. From this perspective, the "mechanistic paradigm" carries a progressive impulse. Then again, both Carolyn Merchant, in *The Death of Nature,* and David Kubrin, in "How Sir Isaac Newton Helped Restore Law 'n' Order to the West," have pointed out how the triumph of the mechanistic world view resulted in a more exploitative attitude toward nature (and women) and the suppression of the more radical egalitarian social movements of that period.[2]

The variety of perspectives on the relationship between theoretical frameworks in science and their social and political implications fascinated me, and in exploring the meaning and significance of mechanism and its alternatives, I ultimately focused on the field of biology. Significantly, the founders of SGSR were also drawn to the systems perspective through their interest in biology and the organizational processes in living systems. Although developments in engineering and management fields are highlighted in the technocratic approach to systems, the emergence of organismic conceptions in biology, psychology, and sociology during the early twentieth century was more important for the evolution of general-systems thought. Of course, biological concepts were interpreted in varying ways within different currents of systems thought, and were often appropriated to reinforce and legitimize managerial applications of systems concepts. Ludwig von Bertalanffy was one of the most influential organismic biologists during the early twentieth century, and his impassioned critique of mechanistic views was linked to his rejection of the "machine view of man" that he saw as inherent in industrial society. On the other hand, Ralph Gerard's organismic conception of society was rooted in a different tradition and was perhaps more closely aligned with the emerging technocratic order.[3]

The two main issues confronting theoretical biologists at the turn of the century were (1) the nature of life and the relationship between biological/psychological and physical/chemical phenomena, and (2) the processes of evolution and development. Questions about the nature of life informed the debates between mechanistic and vitalist orientations that focused on the source of organization in living systems and the nature of consciousness. Organismic biology emerged as an attempt to overcome the dichotomy between these two views and to redefine the relationship between the physical and biological sciences, establishing biology as an autonomous science. In contrast to the primarily reductionist orientation of mechanistic models, which sought to explain biological phenomena primarily in terms of physical and chemical reactions at the molecular level, organismic approaches sought to understand living organisms in holistic, dynamic, and interactive terms.

Organismic perspectives emphasize organizing relations and highlight the concept of *emergence,* the idea that phenomena arising out of the interaction of component parts of a system are more complex than the parts themselves and cannot be explained on the basis of the parts alone. In her discussion of organicism as a new paradigm, Donna Haraway points out the importance of metaphor in the elaboration of new models in science. The metaphor of the organism, central to this new paradigm, highlights the importance of structural coordination as well as the relative autonomy of biology in relation to physics. Ernst Mayr made a similar argument for the autonomy of biology, suggesting that the distinction between the organic and the inorganic is not a question of substance but of organization.[4]

On the other hand, like the systems models that emerged out of organismic biology, organicism was also rooted in analogies between living and nonliving systems. Paul Weiss, whose work shaped the development of Bertalanffy's thought, applied systems concepts from engineering to problems in embryology. Although critical of organismic models, Michael Ghiselin suggests that analogies between different fields can serve a useful and legitimate function in the evolution of science. He cites Darwin's work as an example of the transfer of ideas and ways of thinking from one field to another, in applying concepts from geology and economics to an understanding of biological evolution, and suggests that there may be "far greater unity among natural phenomena." The nature of this unity forms one of the central dilemmas in debates between holistic and reductionist orientations and is a central preoccupation in the evolution of systems theories. Significantly in relation to later critiques, Haraway describes reductionism as an approach based on the assumption of a unified nature, while she suggests that organicists tended to see the world in more pluralistic terms.[5]

A key feature of most organismic models is a rejection of the atomism and reductionism of physics and chemistry. Unlike the vitalists of the late nineteenth and early twentieth centuries, who appealed to immaterial or supernatural forces in their rejection of the mechanistic model, the organicists of the 1920s and 1930s hoped to develop empirically grounded laws to describe the behavior of organisms, shifting the terms of the debate from metaphysical to epistemological grounds. These laws, regarding patterns of integration and organization, would be unique to biology. Two of the earliest organicists, writing in the 1910s, were J. S. Haldane, who was the first to call himself an organicist, and E. S. Russell. Both of them thought that neither vitalism nor mechanism were sufficient to address the problems confronting biology, and believed that the fundamental unit of biology was the whole individual organism. According to Russell, the organismic conception "allows us to look on the living thing as a functional unity . . . and to realize how all its activities . . . subserve in cooperation with one another the primary end of development, maintenance, and reproduction."[6]

In connection with ensuing efforts to explain the functional unity of living systems in scientific terms, biological research in this tradition focused on the nature and genesis of organic form, in connection with contemporary developments in evolution and embryology. Similarly, gestalt psychology emphasized the perception of form as a holistic and evolutionary process. The most significant contributions to the emergence of systems thought from the organismic tradition were its emphasis on (1) the source of organization in complex systems, (2) the role of information in the maintenance of that organization, and (3) the importance of considering any system in relation to its environment.[7]

Haraway identifies three major lineages of organismic thought in the early twentieth century that are relevant to the emergence of systems ideas. The German-speaking group includes the founder of gestalt psychology, Wolfgang Köhler, engineer/biologist Paul Weiss, and Bertalanffy. From England, she identifies two subgroups: the early organicist biologists Haldane and Russell and psychologist C. Lloyd Morgan; and a later group including Joseph Woodger, Joseph Needham, and Conrad Waddington, who were all concerned with problems in embryology and formed part of the Theoretical Biology Group in England, along with Dorothy Wrinch and J. D. Bernal. The third major lineage grew out of the work of the late-nineteenth-century French physiologist Claude Bernard and includes American biologists Walter Cannon and Lawrence Henderson, along with the English neurologist Charles Sherrington. The influence of this last group was most significant in connection with the work of Gerard and James Grier Miller.[8]

Organismic biology was also shaped by a number of parallel developments in other fields. From philosophy, the holistic approaches of Alfred North Whitehead and Jan Christiaan Smuts were particularly important. Miller studied with Whitehead at Harvard, and traces his interest in the integration of biological and social theory to Whitehead's encouragement. Mathematical developments also had a profound impact on the evolution of organismic models, most significantly in the work of Alfred Lotka and Vito Volterra on population dynamics and in D'Arcy Thompson's classical work *On Growth and Form,* which elaborated the mathematical foundations of the science of form. Kenneth Boulding considered Thompson's work central to the evolution of his own thinking, along with that of Lotka, whom he referred to as the "John the Baptist of General Systems." Lotka is also credited with the introduction of the open-system concept, which was further developed in Bertalanffy's work.[9]

Gerard's organismic conception of society was profoundly shaped by Herbert Spencer's early work in sociology, reflecting the ongoing relationship between biological models and social thought. Another important development in connection with the rise of both organismic and molecular biology had to do with the role of information in overcoming the entropic tendencies of matter and allowing for the evolution of complex living systems, which ultimately provided a critical breakthrough in research on the mechanisms of genetic transmission. A consideration of the issues central to debates between vitalists and mechanists in the early 1900s will provide some context for this broad range of developments in biology during the first half of the twentieth century.

VITALISM AND MECHANISM

Central to the debate between vitalism and mechanism is the nature and source of organization in living systems. In general, vitalists argue that physical and chemical laws are not adequate to explain the complex organization and seemingly purposive phenomenon of life, and that some kind of organizing intelligence is necessary to explain the ever-increasing complexity of living forms. Aristotle's notion of final cause (i.e., the purpose for which something is created) is fundamentally a vitalist notion, implying intelligence or purposiveness in the evolution of life. This is reflected in the Aristotelian concept of *entelechy,* defined as the form-giving agency or force that regulates and directs the development and functioning of organisms. The term "entelechy" was adopted by the German biologist Hans Driesch, the foremost spokesman for the vitalist position at the turn of the century, whose work provided inspiration for Bertalanffy's conception of organismic biology. Driesch describes entelechy as an immaterial organizing principle that is responsible for the organization and regulation of inorganic matter in the phenomenon of life.[10]

Another important dimension of the debate echoes the perennial dilemma between free will and determinism, mechanists tending toward a more deterministic orientation and vitalists arguing for the increasing autonomy of organisms at progressively higher levels of organization. Although mechanists might be able to explain the details of life in materialistic terms, Driesch argued that mechanism was incapable of explaining their relationship to the functioning of the whole organism. For him, the autonomy and wholeness of the organism were fundamental and closely interrelated. In contrast with the mechanistic view, which might be seen as focusing on externally imposed laws of nature, Driesch's concept of entelechy posited an intrinsic and autonomous organizing principle. In rejecting mechanistic analogies between the apparent purposiveness of machines and the similarly illusionary purposiveness of human existence, Driesch argued that the former are determined by a static structure, and that the teleology (or purposiveness) of living organisms is dynamic, enabling them to respond to changes in their environment.[11]

Driesch's position grew out of his work on developing sea urchin embryos. According to the prevailing mechanistic theory of development, if he cut the embryo in half in its early stages, each half should develop into half of a sea urchin. What emerged instead were two whole though somewhat smaller sea urchins. From this experiment, he derived the concepts of *equipotentiality* and *equifinality* that were central to the development of Bertalanffy's conception of organismic biology. Equipotentiality referred to the ability of evolving cells to differentiate themselves in response to the pattern of the whole organism. In other words, cells were differentiated in accordance with their position in the developing organism, not according to some predetermined program within each individual cell. Equifinality referred to the ability of the embryo to reach its final state from many different starting points and through different developmental pathways. Rather than being rigidly determined, developmental processes in the embryo were able to adapt to changing conditions, maintaining the integrity of the developing organism.[12]

Jacques Loeb, a contemporary of Driesch, provides a noteworthy example of the mechanistic perspective as it was articulated in early-twentieth-century biology. Reflecting the materialistic reductionism common among biologists during that period, he argued that consciousness and life were merely "epiphenomena" of physical and chemical interactions. In what Philip Pauly describes as his "engineering approach" to biology, Loeb sought to control the behavior of living organisms. He was a pioneer in the objective analysis of behavior, and a precursor and major mentor of the behaviorist psychologist John Watson. He emphasized quantitative analysis, sought to ground ethics in biology, and believed in the power and privilege of science to master the natural world, as reflected in the following passage from *The Dynamics of Living Matter* (1906):

> In these lectures we shall consider living organisms as chemical machines . . . , which possess the peculiarities of automatically developing, preserving, and reproducing themselves. The fact that the machines which can be created by man do not possess [these] powers constitutes for the present a fundamental difference between living machines and artificial machines. We must, however, admit that nothing contradicts

> the possibility that the artificial production of living matter may one day be accomplished. It is the purpose of these lectures to state to what extent we are able to control the phenomena of development, self-preservation, and reproduction.[13]

Loeb's "mechanistic conception" is epitomized in his efforts, also using sea urchins, to stimulate the development of the embryo without the intervention of sperm, anticipating recent efforts at cloning a variety of organisms—plants, animals, and possibly (horrifyingly) even humans.[14]

In connection with later critiques of systems theory, it is important to recognize the roots of such manipulative approaches to humans and nature in the mechanistic tradition, and the central place of antimechanistic conceptions in the formation of Bertalanffy's general-systems view. In contrast to critiques claiming that holistic thinking lends itself to social control, Lily Kay has argued that the potential for social control in the reductionism of molecular biology made it most attractive to the Rockefeller Foundation.[15]

At stake in the vitalist-mechanist debates was the nature of matter and its relationship to life. The dichotomy between these two positions emerges out of the Cartesian separation between mind and matter. This can be traced back even further to the Aristotelian concept of matter as passive, inert, and radically discontinuous from the forces that act on matter and give it form. The seventeenth-century mechanistic models of Descartes and Newton maintained this dualistic orientation, including a transcendent principle to organize and maintain the machine. Although this mechanic was banished in the eighteenth century, Haraway suggests that mechanists were never able to completely rid themselves of the "ghost in the machine," and that "the splits of mind and body, structure and function, efficient and final cause were never sutured during reign of corpuscular philosophy," as Newton's model was commonly known. Vitalism, she argues, was not opposed to the machine theory itself, but rather to the materialism inherent in most mechanistic models. Since the idea of self-regulation had not yet emerged as part of the mechanistic paradigm, Driesch chose to resurrect the mechanic rather than to abandon the machine paradigm.[16]

In contrast, most contemporary mechanists have adopted a notion of matter as dynamic and self-moving, in which the principle of organization is inherent. Steven Pepper describes the difference between these two positions as a transition from "discrete" to "consolidated" conceptions of mechanism. The first is based on the metaphor of the machine, with matter as entirely passive, while the second is rooted in relativistic conceptions of space-time and the equivalence of matter and energy. Leo Szilard's 1929 paper distinguishing information from matter/energy further transformed mechanistic models, providing a materialistic basis for explaining the evolution of organic form, as well as an important key to unraveling the structure of DNA, the "master molecule" of life. Concepts of feedback and homeostasis, emerging out of Claude Bernard's work, provided additional support for explaining life in material terms. As Haraway points out, nineteenth-century mechanists compared organisms with actual machines, while "neomechanists" of the mid-twentieth century, concerned with the molecular basis of genetics, describe the organism/machine relationship in terms of codes, language, and computers. The "machine metaphor" shaping our understanding of biological organisms has thus evolved to reflect the increasing complexity of our technology.[17]

THE EMERGENCE OF ORGANICISM

In "The Endurance of the Mechanism-Vitalism Controversy," Hilde Hein argues for the continuity of issues central to the debate. In her view, the antimechanistic impulse of vitalism is further elaborated in twentieth-century organicism, with its emphasis on holism and emergence in contrast to the reductionist and mechanistic perspectives prevalent in the parallel development of molecular biology. Pnina Abir Am offers an alternative perspective on the relationship between the two fields, identifying the roots of molecular biology in the organicism of the British Theoretical Biology Group (TBG). For her, the metaphor of the organism/system provides a basis for a nonreductionist unity between physics and biology. These varying interpretations can be seen as a reflection of the slightly different orientation of the three lineages identified by Haraway; Bertalanffy clearly positions himself in opposition to the mechanistic view, while the orientations of the TBG and the Claude Bernard School are somewhat more ambiguous.[18]

Haraway describes organicism as an entirely new paradigm, distinct from both vitalism and mechanism. She draws on the work of Philip Ritterbush, who sees romanticism as the starting point for modern biology, citing Samuel Taylor Coleridge's early-nineteenth-century differentiation between organic and mechanical forms in terms that are echoed by organicists a century later. Coleridge emphasizes the priority of the whole over the differentiation into parts, the importance of the process of growth and development in the manifestation of form, and the centrality of internal processes in the determination of the organism. The relationship between form and process was further elaborated by Whitehead, who suggested that the concepts of organization, wholeness, and internal relations provided a foundation for a new unified science, once the certainties of deterministic physics had been shattered by developments in relativity and quantum theory.[19]

Haraway describes the similarity between biological organicism and the emerging concept of structuralism in the social sciences, in their respective concern with organizing relationships. Biological concepts of structure, growing out of insights from crystallography into the nature of molecular structure, were central to the emergence of a nonvitalist organicism. Jean Piaget defines structure as "a system of transformations" and has identified similarities between structuralist approaches in different disciplines. Like organicism, the notion of structure is based on the concepts of wholeness, transformation, and self-regulation. Issues of form in structuralism are dealt with not in terms of a static anatomy, but in terms of systematic and dynamic transformations that conserve the totality.[20]

Bertalanffy's original work in theoretical biology drew heavily on Driesch's work in developmental biology. The challenge of explaining the process of differentiation in embryonic development lies at the heart of organismic conceptions in biology. Two other major influences in the evolution of Bertalanffy's work were gestalt psychology and mathematical biology. In their discussion of systems thinking, Nic Kramer and Jacob de Smit credit Wolfgang Köhler with the first impulse toward general systems theory, in his attempts to explain human behavior using holistic rather than mechanistic principles. What was important for him was the overall configuration of a complex whole rather than the structure of its parts. In his 1924 book on physical *Gestalten,* Köhler sought analogies between organic and inorganic systems that could explain the unique qualities of organic systems. The idea of the open system, introduced initially by Alfred Lotka in his 1925 work on population dynamics, provided an important key to resolving this dilemma. Bertalanffy's development of the open-system concept, which will be discussed at greater length in Chapter 6, marks his major contribution to the emergence of general systems theory.[21]

There are important parallels with Bertalanffy's work in the TBG of Cambridge, England, which included as core members J. D. Bernal, Joseph Needham, Conrad Waddington, Joseph Woodger, and Dorothy Wrinch. Woodger translated Bertalanffy's first major book on development into English, and encouraged the other members of the group to read it. Waddington was one of the members, as was Bertalanffy, of the Alpbach Group, which met in 1968 to address similar issues in theoretical biology. Waddington and Weiss were both interested in the relevance of field concepts, which had already been successfully appropriated from physics in gestalt psychology, to problems in embryology. This line of inquiry built on the earlier work of D'Arcy Thompson on the mathematics of form, drawing Waddington into the field of topology (through the work of René Thom), which was also influential in the work of the general-systems group.[22]

The primary aim of the TBG was to incorporate the power of logic and mathematical explanation into biological thought without adopting the traditional mechanistic framework, focusing instead on hierarchical organization, form, and development as the central concerns of a new theoretical approach to biology. Like the general-systems group, the TBG and the Alpbach Group were seeking a common metaphor that could be applied to different areas of science. In addition to Thompson's influence, Whitehead's organic philosophy of science was important in the development of the TBG's transdisciplinary research program. They sought a new rationale for scientific unity in a theoretical and experimental synthesis that would cut across the fields of biology, chemistry, physics, mathematics, and philosophy, focusing primarily on problems of segregation and differentiation in embryology. The group christened this new program "mathematico-physico-chemical morphology."[23]

The TBG sought a basis for scientific unity in problems of organization, grounded in their recognition of the *isomorphism,* or similarity in form, of structures and processes in physical and biological systems. Abir Am suggests that this conception of isomorphism reflected a pluralistic conception of lawfulness and an insistence upon the epistemological parity between physics and biology, unlike those who see in such concepts another form of reductionism. Echoing the aims of the general-systems community to foster interdisciplinary research, the TBG sought to overcome disciplinary monopolies of scientific authority. Although the Rockefeller Foundation was very interested in supporting such projects in disciplinary synthesis, the reigning powers at Cambridge University were less receptive to such goals, and a check from the foundation that had been sent to support the group's research was returned.[24]

Abir Am's characterization of the sociopolitical context of the TBG is particularly interesting in light of contemporary perspectives on the systems movement. She describes the TBG as socially active, "striving for change in both science and society in the name of avant garde ideals." For the TBG, as for many early-twentieth-century visionaries of progress, including H. G. Wells, biology was seen as the science of the future. Beyond the deterministic models of Newtonian physics, the field of biology was thought to provide unique opportunities for liberation. The TBG's research program was based on a cooperative model of scientific authority, decentralized and participatory rather than hierarchical and centralized. In her description of the interdependence of the cognitive, social, and political components of this group's work, Abir Am portrays their search for scientific unity in pluralistic and participatory terms that echo the goals of the general-systems community, as a "search for transdisciplinary liberation from the oppressive power and paradoxes grounded in the disciplinary monopolies and tight social control constituting the classical scientific order."[25]

The epistemological parity of the physical and biological sciences was grounded in the concept of emergence, which is a central feature in organismic models. In what has become a defining characteristic of systems thinking, emergence implies that the whole cannot be reduced to the sum of its parts or, in other words, that a reductionist approach to understanding the world cannot contain the whole story. In *Emergent Evolution* (1992), David Blitz identifies the key components of the idea of emergence. He describes evolution as a universal process of change, which is capable of producing qualitative novelties (i.e., the emergence in a system of a property not possessed by any of its parts). In addition, reality is seen to be analyzable into levels, each consisting of systems characterized by significant emergent properties, further reinforcing the epistemological independence of different disciplines. In his articulation of an evolutionary holism, Smuts echoes the gestalt psychologists, arguing that the motive force of evolution is the formation of "wholes," which is an inherently creative process, not a mere unfolding of immanent potentialities.[26]

Blitz points out that Darwin saw evolution as continuous and quantitative, supporting the position taken by Ernst Haeckel ("panpsychism") that even inanimate objects possess some level of psychic or mental capacity. Alfred Wallace, on the other hand, who formulated a theory of natural selection independently of Darwin, believed that qualitative novelties could arise through the process of evolution, in particular the phenomena of life and mind. Like the vitalists, however, Wallace attributed these novelties to a supernatural agency. The concept of emergent evolution, as articulated by C. Lloyd Morgan, a comparative psychologist, attempted to combine the recognition of qualitative novelty with a naturalistic evolutionary process. Morgan placed emergence at the heart of a philosophy of evolution and on that basis developed a theory of physical, biological, and psychological levels of reality.[27]

Among the TBG, Needham, in particular, was interested in the idea of levels of organization, which he saw as an evolutionary succession of types of organization from atoms to world commonwealths. The concept of hierarchical levels of organization, central to notions of emergence and preserved in the concept of integrative levels in biology, is also a key feature in the systems view, and has been the focus of much criticism, due primarily to the confusion over different meanings of hierarchy. The influence of Spencer's understanding of evolution as a progression from the inorganic to the organic to the superorganic, in seemingly justifying the subordination of the individual to the social order, also underlies concerns with holistic and organismic models in the social sciences. In contrast, William Morton Wheeler, another early theorist of emergence, posited an innate tendency toward cooperation among humans and other organisms, reflecting Spencer's view.[28]

This concern with levels of organization was rooted in a holistic conception of the natural world and a belief that biological structures could not be understood in isolation, but instead had to be considered in relation to their environmental context. Just as tissues and organs can only be understood in relation to the organism as a whole, so the organism itself must be considered within the larger ecological and social contexts. Higher levels of organization thus become autonomous units, rather than simply aggregations whose identity is wholly determined by their constituent parts. For the neuroscientist Roger Sperry, this holistic view implies a kind of "downward" causation, in contrast to the reductionism and materialism that he identified (and disliked) in such developments as communism in politics and behaviorism in psychology. His description of the "directive holistic form of control," which he thought characterized organismic models, clearly reinforces the critiques. Not all organismic thinkers interpreted holism in terms of downward causation, however. Instead, the relationship was often understood in terms of mutual causality. Nevertheless, an orientation toward top-down control can be seen in the school of thought growing out of Claude Bernard's work in physiology. His most influential students, Walter Cannon and Lawrence Henderson, had a tremendous impact on the evolution of organismic and systems models.[29]

THE CLAUDE BERNARD SCHOOL OF PHYSIOLOGY

Claude Bernard was a mid-nineteenth-century French physiologist who was particularly interested in the organism's ability to maintain a stable internal environment (*milieu interne*) in the midst of a constantly changing external environment. In addition to articulating an experimental approach in biology, he is acknowledged for his work in such areas as digestion, the role of the pancreas and other glands, the regulatory function of the blood in maintaining temperature, and the relationship between the motor and sensory components of the sympathetic nervous system. In line with organismic biologists of the early twentieth century, he believed that vital phenomena were conditioned but not completely determined by physical and chemical factors. He was antireductionist, insisting on the unity of organic processes and the importance of viewing the organism as a harmonious whole. However, unlike his later followers, he did not extend his models to social contexts. And unlike most systems theorists, he did not believe that organic processes could be expressed mathematically, due to the immense complexity and variability of living organisms.[30]

In addition to Haldane, early-twentieth-century biologists associated with Bernard include the English neurologist Charles Sherrington and the Americans Lawrence Henderson, a biochemist, and Walter Cannon, a physiologist, both of whom were at Harvard in the early twentieth century, shaping the evolution of Miller's conception of living systems. All of them were concerned with the functional integration of the various organs and systems in living organisms, especially in the organization and integrative function of the nervous system and its relationship with the endocrine system. Sherrington published *The Integrative Action of the Nervous System* in 1906. Henderson focused on blood chemistry, specifically in terms of the maintenance of the acid/base equilibrium. Growing out of his World War I studies of shock, Cannon became interested in the regulative mechanisms responsible for maintaining homeostasis in the organism. Both Henderson's *The Fitness of the Environment* (1913) and Cannon's *The Wisdom of the Body* (1932) were extremely influential in the elaboration of systems concepts in mid-century America.[31]

Like the British organicists, Henderson and Cannon were trying to overcome what they saw as the limitations of the reductionist approach in biology, emphasizing the integration and coordination of equilibrium processes in the organism. They promoted an interactive view of natural phenomena, in which the attributes of any part in isolation are not the same as when they are interacting with others in a whole. In addition, their work contributed substantially to an understanding of the organism's capacity for internal self-regulation. Historian of biology Garland Allen notes that the general climate of the 1920s fostered integrative approaches in science and refers to their approach as a form of "holistic materialism," which he describes as a middle ground between mechanistic materialism and "all-out idealism." In the latter category he includes vitalism, organicism, and emergence, along with the work of Bertalanffy, reflecting a stronger affinity between the Henderson and Cannon school of organismic biology and traditional mechanistic approaches.[32]

In contrast to the decentralized and pluralistic orientation of the TBG, both Cannon and Henderson contributed to the ideal of centralized social control as an analogy to what they saw as the highly centralized regulatory processes in living organisms. Robert Lilienfeld suggests that Henderson foreshadowed systems theory in his "early and influential use of the term system," which he derived from the physicist J. Willard Gibbs, as well as in his scientism, his passion for quantification, and his "enthusiastic and somewhat simplistic belief that systems models can adequately encompass the totality of a society." Drawing from Vilfredo Pareto's work in sociology, Henderson's systems model of social processes emphasized equilibrium processes and was very influential in the work of Talcott Parsons, Robert Merton, and other sociologists of the period.[33]

Cannon's ideas were enormously influential in the development of ideas about feedback in cybernetics as well as in Parson's social-systems theory. One of Cannon's most influential students (and later colleague) was Arturo Rosenbleuth, who coauthored the 1943 paper "Behavior, Purpose, and Teleology" with Norbert Wiener and Julian Bigelow that triggered the development of cybernetics. Cannon's concept of homeostasis became a general principle to describe the establishment, regulation, and control of steady states for social and industrial organization. In the epilogue to *The Wisdom of the Body,* he drew a number of comparisons between organic and social processes, one example being his discussion of the transportation system in society as analogous to the fluid matrix in the body, with the corresponding task of insuring the flow of necessities to all members of the social organism. Cannon's work parallels the rise of Keynesian economics in its emphasis on planning and regulation over laissez-faire individualism. Just as individual cells resign the problems of regulation to the central nervous system, so the independence of individual members of society is sacrificed in favor of social control and organization.[34]

This emphasis on social control, and the corresponding devaluation of the individual, is the focus of most critiques of systems approaches. Acknowledging an ideological commitment to competitive individualism, Michael Ghiselin reflects a common view among contemporary biologists in preferring the model of the free-enterprise economy (i.e., competitive survival) for analogical comparisons. He sees the holistic orientation of what he calls the "Harvard crypto-vitalists" (including Whitehead, Henderson, Cannon, and Wheeler) as teleological and anti-Darwinian. The problem with extending the idea of homeostasis to society and viewing it as a kind of superorganism is that it depends on the perception of a unity and cohesion among the parts that, he argues, does not exist. From his perspective, Darwin's theory of natural selection precludes any notion of design and undermines the idea that individuals in society exist for the sake of some larger being. Rather than being integrated in the same manner as organs in organisms, individuals in society are, in his view, continually at war with one another.[35]

In contrast to Ghiselin's view, organismic approaches emphasized the importance of cooperation and symbiotic relationships in both ecological and social contexts. Building on the organismic principle of hierarchical order, functionalist models in social theory could be appropriated to reinforce ideologies of social control. On the other hand, the emphasis on organizational processes, which characterized the organismic tradition, inspired some social theorists to explore the role of information and communication in preserving the responsiveness of the system as a whole to its individual members.[36]

The importance of information can be seen in the emergence and development of the field of genetics, sometimes described as the first uniquely and archetypally American science, and the consequent unraveling of DNA, the "master molecule." Whether or not it marked the triumph of the synthetic program promoted by the

Cambridge organicists, as Abir Am suggests, molecular biology highlighted the importance of codes. The problem of information transfer, central to an understanding of genetic processes, challenged physicists of the period, who had never encountered such problems in the inorganic world. Erwin Schrödinger's famous essay, *What Is Life?,* suggested that the code-script contained in the chromosomes could account for the ability of living organisms to overcome the inevitable tendency toward increasing entropy legislated by the second law of thermodynamics.[37]

As the field of molecular biology evolved, Haraway suggests that the concept of the gene became less atomistic, "metamorphosing into a system with structural laws," paralleling the emergence of organicist and structural concepts in developmental biology. Further, as Garland Allen points out in his history of twentieth-century biology, the physicists, including Niels Bohr, Max Delbruck, and Schroedinger, who were interested in applying insights from physics in examining questions relating to information in biological systems (the "informationists"), shared the antimechanistic and antireductionist orientation of the organismic tradition.[38]

In his elaboration of the feedback concept, Cannon provided an important contribution to this growing preoccupation with information and communication systems, marking a major turning point in the transition from organismic to systems models that came about in the 1940s and 1950s. This transition from the metaphor of the organism to that of the system is reflected in the emergence of cybernetics and information theory and the corresponding shift in emphasis from such concepts as integration and homeostasis to a focus on feedback, information, and communication. It was also profoundly influenced by parallel developments in the fields of engineering and management, providing grounds for continuing dialogue between two ostensibly unrelated fields. This dialogue is at the heart of the evolution of systems thought, and the implications drawn from the interaction between technological and biological developments in theories of information and feedback have significant consequences for the further evolution of both ecological and social theory.[39]

NOTES

1. Walter Cannon, *The Wisdom of the Body* (New York: W. W. Norton, 1932/1963), p. 305.

2. Margaret Wheatley, *Leadership and the New Science* (San Francisco: Berrett-Koehler, 1992); Carolyn Merchant, *The Death of Nature: Women, Ecology, and the Scientific Revolution* (San Francisco: Harper and Row, 1980); David Kubrin, "How Sir Isaac Newton Helped Restore Law 'n' Order to the West," *Liberation* (March 1972): 32–41.

3. Ida Hoos, for example, identifies systems analysis with bio-organismic models, in *Systems Analysis in Public Policy: A Critique* (Berkeley: University of California Press, 1972), p. 29. See Debora Hammond, "From Dominion to Co-Creation: A New Vision of Reality Beyond the Boundaries of the Mechanistic Universe," *ReVision: A Journal of Consciousness and Transformation* 21:4 (1999): 4–11, for my own perspective on what a nonmechanistic science might look like.

4. Donna Haraway, *Crystals, Fabrics, and Fields: Metaphors of Organicism in Twentieth-Century Developmental Biology* (New Haven: Yale University Press, 1976), pp. 8–9; Mayr's argument is discussed in David Blitz, *Emergent Evolution: Qualitative Novelty and the Levels of Reality* (Boston: Kluwer Academic Publishers, 1992), p. 162.

5. Michael Ghiselin, *The Economy of Nature and the Evolution of Sex* (Berkeley: University of California Press, 1974), pp. 9–12 (quote p. 9). See Haraway, *Crystals,* pp. 38 (n. 2), 63 (n. 20), regarding Weiss's influence on Bertalanffy.

6. Haraway, *Crystals*, pp. 36–37, 194–205; E. S. Russell, *The Interpretation of Development and Heredity* (Oxford: Clarendon Press, 1930). See also Pnina Abir Am, "The Biotheoretical Gathering, Trans-Disciplinary Authority and the Incipient Legitimation of Molecular Biology in the 1930s: New Perspectives on the Historical Sociology of Science," *History of Science* 25 (1987): 10–11.

7. Abir Am, "Biotheoretical Gathering," p. 1; Haraway, *Crystals,* p. 39. The study of form was rooted in nineteenth-century studies of morphology, influenced particularly by the work of Johann Wolfgang von Goethe, who also had a significant impact on the evolution of Bertalanffy's work. See Lynn K. Nyhart, *Biology Takes Form: Animal Morphology and the German Universities, 1800–1900* (Chicago: University of Chicago Press, 1995), for a discussion of nineteenth-century morphology.

8. Haraway, *Crystals,* p. 38.

9. Kenneth Boulding, Letter to Bertalanffy, Feb. 23, 1959 (KEB/MI, Box 29). See Alfred North Whitehead, *Science and the Modern World* (New York: Macmillan, 1925); Jan Christiaan Smuts, *Holism and Evolution* (New York: MacMillan, 1926); Volterra, *Leçons sur la théorie mathématique de la lutte pour la vie* (Paris: Villars, 1931); Alfred Lotka, *Elements of Physical Biology* (Baltimore: Williams and Wilkins Company, 1925); and D'Arcy Thompson, *On Growth and Form* (Cambridge: Cambridge University Press, 1917). Also Haraway, *Crystals,* p. 44; and Abir Am, "Biotheoretical Gathering," p. 17.

10. Hans Driesch, *The History and Theory of Vitalism* (London: Macmillan, 1914), pp. 12, 18, 31, 178, 180.

11. Driesch, *The History and Theory of Vitalism,* pp. 1, 5, 93. Driesch rejected the attempts of the nineteenth-century "teleomechanists" to account for the purposiveness of life according to mechanistic principles, described in Timothy Lenoir, *The Strategy of Life: Teleology and Mechanics in Nineteenth-Century German Biology* (Dordrecht, Netherlands: D. Reidel Publishing Co., 1982).

12. Horst Freyhofer, *The Vitalism of Hans Driesch: The Success and Decline of a Scientific Theory* (Frankfurt: Peter Lang, 1982), pp. 27–28. It is often thought that cell theory dealt the fatal blow to vitalism. Haraway suggests that, though in some ways it marked the triumph of atomism in biology, through the representation of the organism as an assembly of similar structural units, cell theory also highlighted questions of the relationship between structure and function. Haraway notes that the mid-nineteenth-century debates between Mueller and Schwann over the implications of cell theory were "only partly over the former's avowed vitalism." Rather, their disagreement had to do with the relationship between part and whole. While Mueller thought that the nature of each part was determined by its relation to the whole, Schwann tended to look for causes solely at the cellular level (*Crystals,* p. 12).

13. Jacques Loeb, *The Dynamics of Living Matter* (New York: Columbia University Press, 1906), p. 1.

14. See Jacques Loeb, *The Mechanistic Conception of Life* (1912, reprint Cambridge, MA: Harvard University Press, 1964); Donald Fleming, "Introduction," in Loeb (1964), p. xxii; and Philip Pauly, *Controlling Life: Jacques Loeb and the Engineering Ideal in Biology* (Berkeley: University of California Press, 1987), p. 141. According to Pauly, "Beginning in 1916 Loeb devoted himself completely to the goal of developing a mechanistic conception of life and eliminating 'romanticism' from biology" (p. 147).

15. Lily Kay, *The Molecular Vision of Life: Caltech, The Rockefeller Foundation, and the Rise of the New Biology* (Oxford: Oxford University Press, 1993).

16. Haraway, *Crystals,* pp. 6, 19, 28, 31. Haraway's ghost is an allusion to Arthur Koestler, *The Ghost in the Machine* (New York: Macmillan, 1968).

17. Hilde Hein, "The Endurance of the Mechanism-Vitalism Controversy," *Journal of the History of Biology* 5:1 (spring 1972): 164; Steven Pepper, *World Hypotheses: A Study in Evidence* (Berkeley: University of California Press, 1942), pp. 186–187, 195–215; Leo Szilard, "Über die Entropieverminderung in einem thermodynamischen System bei Eingriffen intelligenter Wesen," *Zeitschrift fur Physik* 53 (1929): 840; Haraway, *Crystals,* pp. 196, 205. Hein associates the second form of mechanism with the "materialism" of Spinoza, which has had a significant influence on the twentieth-century conception of materialism.

18. Hein, "The Endurance of Mechanism"; Abir Am, "Biotheoretical Gathering," pp. 10, 27.

19. Haraway, *Crystals,* p. 17; Philip Ritterbush, *The Art of Organic Form* (Washington, DC: Smithsonian Institute Press, 1968), pp. 7, 20–21 (cited in Haraway, *Crystals,* pp. 39–40); also Whitehead, *Science and the Modern World*.

20. See Jean Piaget, *Structuralism,* trans. C Mascher (New York: Harper and Row, 1971), p. 5 (cited in Haraway, *Crystals,* p. 61); also pp. 3 (n. 2), 24, 189.

21. See Nic J.T.A. Kramer and Jacob de Smit, *Systems Thinking: Concepts and Notions* (Leiden, Netherlands: H. E. Stenfert Kroese B. V., 1974), pp. 2–3. Köhler's early work can be seen in *Die Physischen Gestalten in Ruhe und im stationären Zustand* (Erlangen: Philosophische Akademie, 1924) and "Zum Problem der Regulation," *Roux's Archive* 112 (1927). Lotka's introduction of the open-system concept can be found in *Elements of Physical Biology*. Bertalanffy writes that von Ehrenfels, a psychologist writing in 1890, was the first to approach the problem of wholeness scientifically, suggesting that it was impossible to resolve perception into a mere sum of elementary sensations. Bertalanffy notes that the philosopher Nicolai Hartman had argued in 1912 for a system conception that incorporated a consideration of interaction. See Ludwig von Bertalanffy, *Problems of Life: An Evaluation of Modern Biological Thought* (New York: Wiley, 1952), pp. 189–192, 196.

22. Ludwig von Bertalanffy's *Kritische Theorie der Formbildung* (Berlin: Borntraeger, 1928) was published in English as *Modern Theories of Development* (London: Oxford University Press, 1933). See Haraway, *Crystals,* pp. 38, 55, 60; and Abir Am, "Biotheoretical Gathering," p. 17. Haraway (p. 63) points out that Jean Piaget credited Bertalanffy with being the first biologist to develop a solid foundation for a structuralist organicism (see Piaget, *Structuralism,* chapter on "Physical and Biological Structures"). See also Abir Am, "Biotheoretical Gathering," p. 16, on the relevance of fields to morphogenesis.

23. See Haraway, *Crystals,* pp. 4–5; and Abir Am, "Biotheoretical Gathering," pp. 3, 12–14, 55 (n. 5).

24. Abir Am, "Biotheoretical Gathering," pp. 10, 18, 24, 28, 33.

25. Ibid., quotes pp. 9, 28; see also pp. 1, 18, 20–21, 27.

26. Blitz, *Emergent Evolution,* pp. 1–2.

27. Ibid., p. 59. See also Ernst Haeckel, *The Riddle of the Universe* (New York: Harper and Brothers, 1900); and C. Lloyd Morgan, *Emergent Evolution* (London: Williams and Norgate, 1923). Haraway provides a slightly different perspective in her suggestion that organicist structuralism was different from both the additive point of view represented in mechanism and philosophies of emergence that she identifies with vitalism (*Crystals,* p. 9). Ghiselin points out the importance of Morgan's work in the development of Whitehead's "cryptovitalist" organic philosophy of science (*Economy of Nature,* p. 31).

28. Blitz, *Emergent Evolution,* pp. 59, 113, 136. In addition to Morgan and Wheeler, Blitz also discusses the contributions of Samuel Alexander, C. D. Broad, and Roy Wood Sellars to the notion of hierarchical levels of organization, some of whom include society

among the higher levels (see pp. 113, 125). See also Abir Am, "Biotheoretical Gathering," pp. 12, 15, 198; Smuts, *Holism and Evolution;* and Nicolai Hartman, *Neue Wege der Ontologie* (Stuttgart: W. Kohlhammer, 1949). In his critique of organicism, Ghiselin is particularly critical of Wheeler's views on cooperation (*Economy of Nature,* p. 223).

29. Blitz, *Emergent Evolution,* pp. 161–163. Blitz draws on the arguments of Ernst Mayr to illustrate this perspective, referring specifically to Sperry's work in "A Modified Concept of Consciousness," in *Psychological Review* 76 (1969): 532–533. See discussion of Anatol Rapoport's work, in Chapter 7, on mutual causality. Haraway points out that Haldane also emphasized the importance of considering not only parts in relation to the whole, but the organism in relation to its environment (*Crystals,* p. 36).

30. Reino Virtanen, *Claude Bernard and His Place in the History of Ideas* (Lincoln: University of Nebraska Press, 1960), pp. 17–21, 61, 76, 81. See also Frederic Holmes, *Claude Bernard and Animal Chemistry: The Emergence of a Scientist* (Cambridge, MA: Harvard University Press, 1974). Bernard's classic work, *Introduction à l'étude de la médecine expérimentale* (Paris: Ballière, 1865), was published in English in 1927, with an introduction by Henderson. Virtanen suggests a parallel between Bernard's work and both pragmatism and P. W. Bridgman's operationalism (*Claude Bernard,* p. 17).

31. See Garland Allen, *Life Science in the Twentieth Century* (New York: Wiley, 1975), pp. xviii, 74, 82–83, 88, 100; Holmes, *Claude Bernard,* pp. 20–21; Haraway, *Crystals,* pp. 35–36; Charles Sherrington, *The Integrative Action of the Nervous System* (New York: C. Scribner's Sons, 1906); Lawrence Henderson, *The Fitness of the Environment: An Inquiry into the Biological Significance of the Properties of Matter* (New York: Macmillan, 1913); and Cannon, *The Wisdom of the Body.*

32. Garland Allen, *Life Science in the Twentieth Century* (New York: Wiley, 1975), pp. xviii–xxi, 94–97, 103–104.

33. Robert Lilienfeld, *Rise of Systems Theory: An Ideological Analysis* (New York: John Wiley, 1978), pp. 12–14. See J. Willard Gibbs, *Elementary Principles in Statistical Mechanics, Developed with Especial Reference to the Rational Foundation of Thermodynamics* (New York: C. Scribner's Sons, 1902); John Parascondola, "Organismic and Holistic Concepts in the Thought of L. J. Henderson," *Journal for the History of Biology* 4:1 (spring 1971): 63–113; and Bernard Barber, ed., *L. J. Henderson on the Social System* (Chicago: University of Chicago Press, 1970). Illustrating Henderson's anticipation of systems theory is a quote from Barber (pp. 136–139): "In a social system all factors are mutually dependent or interactive. . . . The mathematical formulation necessary to describe the mechanical system would be formally identical with that necessary to describe the analogous social system" (cited in Lilienfeld, *Rise of Systems Theory,* p. 13).

34. George Richardson, *Feedback Thought in Social Science and Systems Theory* (Philadelphia: University of Pennsylvania Press, 1991), pp. 52, 94; Arturo Rosenbleuth, Norbert Wiener, and Julian Bigelow, "Behavior, Purpose, and Teleology," *Philosophy of Science* 10 (1943): 18–24; Cannon, *The Wisdom of the Body,* pp. 305–322; Holmes, *Claude Bernard,* p. 24; Lilienfeld, *Rise of Systems Theory,* pp. 15–16; and Allen, *Life Science,* pp. 109–110.

35. Ghiselin, *The Economy of Nature,* pp. 13–43. Similar arguments have been made against the Gaia hypothesis of James Lovelock.

36. See Anthony Giddens, *Social Theory and Modern Sociology* (Cambridge: Polity Press, 1987), p. 74.

37. Evelyn Keller, *Refiguring Life: Metaphors of Twentieth-Century Biology* (New York: Columbia University Press, 1995), p. 47; Erwin Schrödinger, *What Is Life? The Physical Aspect of the Living Cell and Mind and Matter* (Cambridge: Cambridge University Press, 1967/1944).

38. Haraway, *Crystals,* pp. 8–9; Allen, *Life Science,* pp. 197, 227.

39. See Donna Haraway, *Simians, Cyborgs, and Women: The Reinvention of Nature* (New York: Routledge, 1991), pp. 15, 44.

THREE
Engineering, Management, and the Military-Industrial Complex

> Many of the organizations I experience are impressive fortresses. The language of defense permeates them. . . . For most of its written history, management has been defined in terms of its control functions. . . . If organizations are machines, control makes sense. If [they] are process structures, then seeking to impose control through permanent structure is suicide. If we believe that acting responsibly means having our hands into everything, then we cannot hope for anything except what we already have—a treadmill of effort and life-destroying stress. . . . As we let go of the machine models of work, we begin to step back and see ourselves in new ways, to appreciate our wholeness, and to design organizations that honor and make use of the totality of who we are.
>
> —Margaret Wheatley, *Leadership and the New Science*[1]

Having been introduced to the system concept in the contexts of biology and new-paradigm thinking, I was neither aware of nor particularly interested in parallel concepts in the fields of engineering and management. I knew very little about cybernetics and had no idea that the field of systems thinking had anything to do with the military. My own orientation, like that of many in my generation, was closer in spirit to the romantic tradition, an organic holism that was both antimechanistic and antitechnocratic. Despite the fact that most of my graduate school colleagues in the early 1990s shared my concerns about the increasingly technocratic orientation of the military-industrial complex, I was surprised to discover that romanticism and organic holism were somewhat suspect in the academic community and often associated with fascism.

Norbert Wiener's contribution to the field of cybernetics clearly grew out of his work on self-correcting weapons systems; cybernetics is most often understood in this context. Yet Wiener's work reflects far more ethical and humanistic concerns than is generally recognized, and he himself became increasingly critical of the military-industrial complex over time, as did many scientists during the postwar era, including Robert Oppenheimer, the father of the first atomic bomb. One of my most important discoveries in the process of my research was the complexity and ambiguity of the moral, ethical, and political dimensions of these developments. I began to realize that the tendency to accuse a person or idea of permanent complicity with the forces of darkness because of an association with the military, of which I myself was guilty, represents an overly simplistic and dogmatic interpretation. The challenge is to redirect the tremendous energy and resources that are mobilized in the service of war toward more constructive and peaceable ends.

James Miller's behavioral-science group had the strongest connections with the military and other branches of the federal government. Miller himself was involved with setting up psychological testing protocols for the Office of Security Services, the precursor to the Central Intelligence Agency. Ralph Gerard traveled often as a scientific ambassador to the Soviet Union, and much of the group's collaborative research was funded by the air force, which provided extensive support for the development of systems analysis in connection with the RAND Corporation. In contrast, neither Ludwig von Bertalanffy nor Kenneth Boulding had any significant military or governmental connections. Boulding was a Quaker and a conscientious objector during World War II, and became actively involved in the antiwar movement of the 1960s and 1970s, as did Anatol Rapoport. Bertalanffy was at Chicago in 1937–1938 and tried unsuccessfully to obtain a permanent position in the United States at that time. Forced to remain in his native Vienna, he was unfairly accused of being sympathetic with the Nazis; the war years were particularly difficult for him, and he eventually managed to emigrate to Canada in 1949.

World War II provided an ideal testing ground for the new systems ideas in connection with both technological and organizational developments. The increasing sophistication of emerging defense technologies required increasingly complex logistical analysis, ushering in the fields of operations research and systems analysis. These fields were further developed after the war in industry and government, as both became increasingly characterized by large-scale organization. The military was also instrumental in the development of computer technology, which made it possible to solve the complex sets of mathematical equations that constituted the initial methodology of operations research and systems analysis. More importantly, however, computers facilitated novel techniques of simulation and modeling, fostering powerful new methods of scientific inquiry and profoundly shaping the future direction of systems research, as well as the later development of chaos and complexity theories.

This constellation of developments, which I have characterized as the technocratic dimension of the systems movement, can be seen as an extension of trends that began in the progressive era. In *The Search for Order,* Robert Wiebe describes the progressive movement as the triumph of the bureaucratic mentality, characterized by values of "continuity and regularity, functionality and rationality, administration and management." In connection with the dramatic social changes brought about by the industrial revolution, problems of organization and management became paramount, given the need to coordinate the technological and human dimensions of emerging industries. The complexity of industrial society necessitated an increasingly interdisciplinary approach to problem solving. Large-scale technological systems, such as transportation, communication, and the production and distribution of energy, called for new kinds of organizational skills to implement and manage these systems.[2]

The growth of large-scale social organizations, made both possible and necessary by technological innovations, stimulated a growing interest in "systems," and systems analysis became an umbrella term applied to almost any kind of broad interdisciplinary research. By mid-century, the rise of systems thinking was reflected in a wide variety of fields, in such diverse developments as Walter Cannon's work on feedback and homeostasis in biological organisms, the emergence of cybernetics, the rise of Keynesian economics, and the efforts of social scientists across a broad spectrum of disciplines to become more rigorously "scientific." The engineers' conception of systems had a considerable influence on developments in biological and social thought. The emergence of such fields as industrial relations, organization theory, and social psychology all dealt with issues relating to people in organizations, and reflected the increasing difficulty of coordinating the evolving complexities of technological systems and the social relations they entailed.

In *American Genesis,* Thomas Hughes documents the technological enthusiasm that characterized the United States during the first half of the twentieth century, describing it as "a nation of machine makers and system builders," embodying the values of "order, system, and control." While technology is generally seen as the fruit of democracy and free enterprise, Hughes argues that the implementation of these increasingly complex technological systems involved organizational structures that became increasingly centralized and undemocratic. In celebrating the inventiveness of their entrepreneurs, U.S. citizens often failed to understand the embeddedness of these inventions in complex technological and organizational systems. Such systems entail much more than machines and factories, and the transportation, communication, and information networks that interconnect them; most importantly, they involve people and organizations. The attempt to understand (and in some cases control) these organizational structures and processes is perhaps at the heart of the development of systems ideas. Boulding reflects a more critical orientation in his discussion of the ethical implications of these dramatic changes in the scope of organizations in *The Organizational Revolution* (1953).[3]

Hughes defines technology as the effort to organize the world for the production of goods, identifying Henry Ford's development of mass-production techniques and Frederick Taylor's pioneering efforts toward scientific and rational approaches to management as the essence of the American achievement. In fact he describes Ford as the archetypal system builder, reflecting America's desire to "rationally organize the second creation to serve our ends." These techniques of order and control were aimed at creating a world of "our own design." The inventions and discoveries of the industrial scientists became part of large systems of production that expanded impressively during the interwar years. Although the Depression may have temporarily dampened technological enthusiasm, the emergence of new levels of government involvement gave it a boost through such projects as the Tennessee Valley Authority and, with the coming of World War II, the Manhattan Project.[4]

Given such powerful means of transforming both the natural and social order, the question of appropriate and desirable ends, addressed in the early years of the century by such solitary voices as Lewis Mumford's, became increasingly problematic in the 1960s, which marked a widespread reaction against the rise of technological systems and the associated values of order, system, and control. It was also a reaction against the culture of war that seemed to be inextricably tied to this technological rationality. Hughes suggests that, with a more critical perspective on the history of technology, "Americans will realize that not only their remarkable achievements but many of their deep and persistent problems arise, in the name of order, system, and control, from the mechanization and systematization of life and from the sacrifice of the organic and the spontaneous." Ironically, however, the reaction against this technological rationality, along with accompanying concerns regarding its environmental costs, was often articulated in systems terms, highlighting the varying and conflicting interpretations of the systems concept.[5]

Initially, technology seemed to offer the potential for more liberating forms of social organization. Both capitalism and Marxism were predicated on the belief in technological progress and its potential for social improvement. But, as David Noble points out in *America by Design,* far from fostering social change, technological developments were absorbed into and actually reinforced existing social structures. "The development of technology, and thus the social development it implies, is as much determined by the breadth of vision that informs it, and the particular notions of social order to which it is bound, as by the mechanical relations between things and the physical laws of nature." Noble then goes on to explore the relationship between modern technology and the social-organizational structure of corporate capitalism that constrains the direction of technological development.[6]

In Marxist terms, Noble describes the second phase of industrial development as the capitalist appropriation of technological knowledge. In a "realization of Veblen's ideal society" (with the engineers in charge of managing society), technology becomes social production and the professional engineer becomes an expert "not only in applied science but in the management of social relations." This form of social engineering is based on the expropriation of the worker's technical knowledge, which has become concentrated in modern management, as the worker increasingly becomes an appendage to the machine, with neither knowledge of nor control over the process. Rather than developing a point of view based on efficiency rather than profit, as Veblen had hoped, "the engineers placed their expertise at the service of a productive system efficient in its details but supremely wasteful and irrational in its general tendency." Reflecting his concern with such limited conceptions of efficiency, Boulding often cited what he called the problem of suboptimization, which he defined as finding the very best way to do something that should not be done at all.[7]

Perhaps the clearest indication of this overriding irrationality is the industrial system's ongoing dependence on military spending and war, fueling concerns of critics of the system concept, who tend to focus on its military origins. In the beginning of the century, World War I provided an opportunity to put these new ideas about industrial organization into practice, initiating an ongoing partnership between corporations, universities, and the state. And, of course, the real flowering of the technocratic mentality came during World War II and the postwar era. Three core components of the evolving systems view—cybernetics, operations research, and the development of the computer as a powerful tool for modeling complex systems—grew directly out of military projects. In addition, such related developments as game theory, communications research, and large-scale systems engineering were integral parts of military strategy during this period.[8]

Christopher Simpson, in *Science of Coercion,* has written an account of the military roots of communication research, which emerged within the field of sociology in the early 1950s in connection with government programs in psychological warfare. He claims that perspectives on the nature of communication arising from these roots formed the intellectual foundation for current educational training in such fields as journalism, public relations, and advertising. Military, intelligence, and propaganda agencies, including the Department of Defense and the Central Intelligence Agency, provided substantial support for postwar research into "techniques of persuasion, opinion measurement, interrogation, political and military mobilization, [and] propagation of ideology."[9]

Communication research, Simpson argues, thus became a tool for social management. In his commentary on Claude Shannon's original articulation of information theory, Warren Weaver defines information as "the means by which one mind may influence another," reinforcing the conception of communication as a mechanism of control. According to Simpson, most academic research on communication was based on the assumption that mass communication was "appropriately viewed from the perspective of the top or power center rather than from the bottom or periphery of the system." Such an orientation toward the meaning of communication, far from fostering understanding or the resolution of conflicting interests, formed "an integral part of a strategy and culture whose premise [is] the rule of the strong at the expense of the weak, where coercion and manipulation pose as 'communication' and close off opportunities for other, more genuine, forms of understanding." Simpson notes the role of the Ford and Carnegie Foundations in funding emerging research in the behavioral sciences and argues that they were closely associated with government propaganda and intelligence programs. On the other hand, my own research suggests that not all work funded by those foundations can be understood in such narrow terms; among the CASBS fellows, for example, there were significant efforts in the areas of conflict resolution and "bottom-up" communication.[10]

OPERATIONS RESEARCH, SYSTEMS ANALYSIS, AND MANAGEMENT SCIENCE

Like cybernetics, the related fields of operations research, systems analysis, and management science emerged in connection with World War II, growing directly out of the expansion of technological engineering into the province of "human engineering." Although management science can be traced back to the early work of Frederick Taylor in "scientific management" and other early-twentieth-century developments in the field of "industrial relations," it blossomed as a field of study after the war, at which time it was profoundly influenced by parallel developments in operations research. In addition to its engineering orientation, this complex of fields is most closely related to the emerging field of econometrics, with its emphasis on maximizing productivity through the mathematical analysis of costs and benefits. For many in the operations research field, the "systems approach" was equivalent to the linear programming models that were employed in such analysis.[11]

Operations research actually originated in Britain during World War I, where it was known as operational research. The operational offices of the British military brought together a number of different specialists to deal with such challenges as poison gas and increasingly powerful tanks. By World War II, one of the major military challenges was coordinating radar signals in the search for German submarines. This was primarily an exercise in applied mathematics. In her critical analysis of systems theories, Ida Hoos provides a summary of the systems engineer's modus operandi: (1) define system and components, (2) formulate mathematical model, (3) determine system equations, (4) solve for desired output, (5) check solution, and (6) analyze or design. In general the purpose of operations research was to make existing systems work more effectively. There were no computers in the early years, which limited the capacity for solving complex logistical problems, although today systems analysis is generally associated with advanced computer programming.[12]

The Operations Research Society of America (ORSA) and the Institute of Management Science (TIMS), two closely related organizations, grew substantially during this period. Harold Linstone, a member and former president of ISSS (formerly SGSR), points out that very few members of these organizations were interested in the broader focus of the SGSR and that most of them weren't even aware of the existence of general systems theory. ORSA, for example, grew to a membership of around 20,000, while the SGSR/ISSS reached about 800 to 1,000 members at its peak. Despite Hoos's claim that general systems theory provided the theoretical basis for systems analysis, these two fields emerged relatively independently. Besides, any influences that might have existed between the two fields would have been primarily in the opposite direction.[13]

With the development of nuclear weapons, the military became increasingly dependent upon technical scientific advice. Few if any of the military commanders had adequate knowledge of nuclear technology to formulate military strategy. Of all the armed forces, the air force was the most amenable to civilian input, and they funded extensive research in the area of systems analysis and system design, some of which was in areas only remotely connected to immediate military concerns. Eventually, growing out of research efforts at Douglas Aircraft, the air force decided to set up an independent research group that was to become the RAND Corporation, the archetypal brain trust of the Kennedy/McNamara era. Robert McNamara had started his career at the Ford Motor Company (highlighting the archetypal significance of Ford in this constellation of developments), and his appointment as secretary of defense is representative of the increasingly corporate approach to government. Economists were prominent among researchers at the RAND Corporation, and there was a pronounced tendency during the Kennedy and Johnson years to bring people from RAND into the government.[14]

Similar in spirit to the community of systems analysts at RAND was the International Institute for Applied Systems Analysis (IIASA). The impetus for an international forum on systems analysis was the Soviet launching of *Sputnik* in 1958. At the time, Europeans recognized the United States' lead in the systems field, and hoped to create a forum after the RAND model for research into problems of common interest, such as energy and environmental issues. The funding for IIASA came primarily from national academies of science, including the U.S. National Science Foundation. The Soviet Union was also represented as second in command.[15]

According to Linstone, the first use of the term "systems analysis" was at Bell Telephone Labs. Researchers from Bell Labs joined Hughes Aircraft in the late 1940s and began to apply concepts of systems analysis, as they had been developed in association with the telephone system, to the design of other systems, specifically air-to-air guided missiles. Most of the early work in systems analysis was in connection with the aerospace sector, an industry closely affiliated with the military. A classic example was George Lamay's study of bomber bases, which saved the air force millions of dollars. It was a very short step from such military applications of systems analysis to applications in other sectors of government, as well as in long-range corporate planning and technological forecasting.[16]

Even military applications of systems analysis were sometimes problematic, primarily due to conflicts between the analysts and the professional military. However, in general, most military applications dealt with concrete technological problems. During the Kennedy and Johnson years, it became increasingly popular to apply similar methodologies to other departments of government. Because they entailed a far greater emphasis on social dimensions, systems analysis in these areas was much more difficult to apply and far less effective, leading to a growing disillusionment with both systems analysis and systems thinking in general. When Richard Nixon was elected in 1968, he cut many of the programs that had been implemented. Linstone suggests that the gap between the analysts/modelers and the real world was too great. He describes Jay Forrester's attempts to apply engineering techniques to the analysis of social problems using systems dynamics models in similar terms. While such models may provide certain insights, they cannot be relied on to reflect the whole situation. For the members of the general-systems community, the growing awareness of the limitations of such quantitative and technocratic approaches highlighted the importance of incorporating a multiplicity of perspectives in studying complex systems.[17]

Another important theoretical development, closely related to systems analysis, is the emergence of game theory, based on the initial work of John von Neumann and Oskar Morgenstern. In his primer on game theory, J. D. Williams suggests that linear programming and game theory converged in the mid-1940s, especially in connection with research groups at Princeton University and the RAND Corporation. He points out that the primary methodologies common to both fields grew out of George Danzig's simplex method of linear programming, which also became an essential tool for both operations researchers and systems analysts.[18]

Game theory was primarily aimed at questions of strategy, and Williams suggests that the field was initially focused on military issues and has thus been mainly addressed to conflict situations. Most of game theory deals with two-person zero-sum games where the two players have opposing interests; what one wins the other necessarily loses. Game-theoretical analysis is based on the assumption that such opposing interests can be measured; it consists of counting sets of opposing interests and developing a set of strategies with their corresponding payoffs, which then allows a player to determine the strategy that will bring about maximum gain with minimum loss. Most telling is the assumption that both opponents are intent upon each other's destruction. And, unfortunately, this becomes the dominant model of rational behavior. In contrast, much of Anatol Rapoport's work in game theory revolved around his efforts to elaborate a more cooperative, non–zero-sum model of rationality.[19]

This constellation of fields—operations research, systems analysis, and game theory—is distinct from the application of feedback concepts to problems in business and government, in what George Richardson has labeled the *cybernetic* and *servomechanistic* traditions, to be discussed in further detail in Chapter 4. Although all of these developments were closely related and mutually influential, they represent distinct lines of evolution with different sets of assumptions. Much confusion has been generated by the tendency to lump these diverse fields together into a single category. Nevertheless, all of these fields, including cybernetics and the servomechanistic tradition, can be seen as part of the professionalization of management and administration that accompanied the postwar expansion of corporate capitalism and increasingly bureaucratic forms of government.[20]

In their overview of the history of systems thinking, Nic Kramer and Jacob de Smit identify Stafford Beer, Russell Ackoff, West Churchman, and Herbert Simon as foremost among scientists who applied systems thinking to management problems. The first three were prominent figures in the general-systems community, as well as in what Richardson has called the cybernetic strand of feedback thinking. Simon's work was more closely aligned with the servomechanistic strand of feedback thought represented in the systems dynamics group, which emerged out of Forrester's work and focused on the use of computer simulation in the management of complex systems. Among more recent practitioners from the latter tradition, Chris Argyris, Donald Schon, and Peter Senge have had considerable impact on contemporary management theory. Also significant in the evolution of the general-systems tradition were the sociotechnical models of the Tavistock group, particularly in terms of their efforts to address ethical concerns in management.[21]

Herbert Simon's work on organization theory and human decisionmaking processes has been tremendously influential across the entire spectrum of systems thought. Simon describes his work as a form of mathematical social science and distinguishes it from the probabilistic approach of game theory. He suggests that most social applications of mathematics tend to downplay the importance of calculus, in favor of set-theoretical and algebraic formulations. In the spirit of the general-systems theorists, he quotes nineteenth-century mathematician Joseph Fourier: "Mathematical analysis . . . brings together phenomena the most diverse, and discovers the hidden analogies which unite them." And yet, again echoing the general-systems perspective, he argues that we must take seriously the "limits of human capacity for calculation" and appreciate both the rational and nonrational nature of "administrative man." Reflecting similar concerns in the cybernetic tradition, George Homans focuses on questions of motivation, learning, and group interaction.[22]

Simon associates his work with the fields of (1) economics, in connection with the theory of the firm; (2) social psychology, in connection with small-group theory; (3) political science, in connection with the phenomenon of power; (4) learning theory, in connection with problem solving; and (5) statistics, in connection with issues of identification. He is seeking a "rigorous and testable theory of human behavior in groups and organizations" that will accommodate the dual nature of humans as both social and rational animals. He bases his work on what he sees as the two primary mechanisms of influence and choice. Echoing Boulding's analysis, Simon argues that organizations depend upon the decision of the employee to belong, exploring the nature of the influences that "link together the behaviors of the individual members of an organization . . . [into] a patterned, interconnected system," and make employees into "instruments" of organizational goals linked only indirectly with their own personal motivations. It is the coercive potential of such forms of influence that is the target of most critiques of the systems approach. And of course many object to the notion that human behavior can be subjected to such "rigorous and testable" analysis.[23]

However different these various approaches might have been, from systems analysis and operations research to organization theory, they were all highly interdisciplinary and concerned with practical solutions to real-world problems. In that sense, they were often at odds with the disciplinary and theoretical focus of the traditional academic environment. Educational programs in systems thinking, most of which were established between the 1950s and the 1970s, tended to combine economics, mathematics, management, engineering, and social psychology. Programs in such fields as public health and environmental and urban studies also tended to entail a systems-oriented approach. In spite of the growth of a number of such interdisciplinary programs, Linstone suggests that it was often easier to do systems work in military and corporate environments, and that systems science was not considered "real" science within the more traditional and narrowly focused academic community.[24]

Peter Checkland's work on the application of systems thinking to management, strongly influenced by Russell Ackoff, emerged out of his association with the Department of Systems at the University of Lancaster in England, which began as a department of systems engineering. Checkland points out that for most people in the 1970s the systems approach meant using computers in solving problems, although later it came to mean taking a broader view, taking all aspects of the problem into account, and looking at the interactions between different aspects of the problem. He describes the systems approach as an attempt to integrate theory and practice in addressing problems of management "broadly conceived." He suggests that traditional science is limited when dealing with real-world problems of management, which are concerned with means and ends, and that systems theory arose out of the engineer's need to solve problems of designing and implementing "controllable complexes of equipment," not just isolated components. Systems analysis was a means of appraising the alternatives facing the decisionmaker. According to Checkland, systems engineering and systems analysis were basically the same thing, primarily concerned with the more technologically oriented, or "hard," approaches to understanding systems. In contrast, he suggests that in dealing with the "softer" (i.e., relational, subjective, or normative) issues of management, the designation of objectives itself becomes problematic. Social systems necessarily involve a consideration of roles, norms, values, and world images.[25]

In discussing their work with the Tavistock Institute and the relationship between their theory of sociotechnical systems and organization theory, F. E. Emery and E. L. Trist identify themselves as social psychologists. They worked closely with Ackoff at the Management and Behavioral Science Center of the Wharton School of the University of Pennsylvania. In his foreword to their book, *Towards a Social Ecology,* Geoffrey Vickers, a former president of SGSR, points out that the institutions that sustain urban life are social organizations, a fact he suggests that the industrial age overlooked. Business organization is thus a *socio*-technical system, "functioning as a whole only in so far as its social organization gives it inner coherence." He further suggests that there are conflicts of scale between the technological and social dimensions of such systems. Though the word "system" is in constant use, he argues that its meaning is often restricted and its human implications still far from accepted: "These include the acceptance of limitation; of mutual obligation; and of a sense of time which extends the present deep into the future as the concern of men now. And all this is implied as the inescapable consequence of the net of relations which alone can sustain our present societies, preserve our heritage and give our aspirations any hope of realization."[26]

Noting the faster rate of change associated with the second industrial revolution, based on information technology accelerated by war efforts during World War II, Emery and Trist suggest that the greater complexity and faster rate of change lends greater importance to the planning process. They fear that the growing antiscientific ethos could undermine the potential for more collaborative forms of social and technical innovation. In this sense, they reflect the generally more optimistic orientation of the systems thinkers. Although we have moved, technologically and structurally, into a postindustrial phase, they argue that we have not yet evolved an appropriate cultural framework. They suggest that we need new values: "A new art of living will have to be learned," which depends upon "interdependent systems of personal values, organizational forms and modes of political regulation." Echoing Simon's consideration of influence, they argue that "such values are unlikely to establish themselves unless a new social context emerges through the spread of trans-bureaucratic organizations and the creation of a common 'ground' through the influence of the media of information technology." Although I am sympathetic with their views on the acceptance of limitation, mutual obligation, and a concern for the future, the idea of "trans-bureaucratic organizations," reinforced through the influence of information technology, raises the specter of a "brave new world," one in which we seem already to be living.[27]

At the same time, they call for a form of politics based on "adaptive planning" to regulate the rapid and uneven change characterizing the current situation, which will embody an "acceptance of pluralism and the surrender of power." One has to ask just who is to surrender power. This tension between the recognized need for pluralism and the desire for influence or control is absolutely critical to a consideration of the impact of systems thinking, and forms the basis for distinguishing "hard" and "soft" approaches within the field. The "softer" aspects of management are closely related to parallel developments in social and political theory. In order to address the significance of systems thinking in those fields, however, it is necessary to provide some background on the synthesis of biological and technological developments in the field of cybernetics, which will be discussed in the following chapter. Having begun this project with very little interest in the field of management, it is noteworthy that my quest became increasingly focused on the question of whether or not more truly democratic approaches to managing human affairs might be possible and, if so, what they might look like. It was gratifying to find that several members of the general-systems community shared my concerns and offered some intriguing perspectives in relation to my question.[28]

NOTES

1. Margaret Wheatley, *Leadership and the New Science* (San Francisco: Berrett-Koehler, 1992), pp. 12, 16, 22–23.

2. See David Donald's foreword to Robert Weibe, *The Search for Order, 1877–1920* (New York: Hill and Wang, 1966), p. viii.

3. Thomas Hughes, *American Genesis: A Century of Invention and Technological Enthusiasm* (New York: Penguin, 1989), p. 1; Kenneth Boulding, *The Organizational Revolution: A Study in the Ethics of Economic Organization* (New York: Harper, 1953).

4. Hughes, *American Genesis,* pp. 3 (quote), 6–8. See David Noble, *America by Design: Science, Technology, and the Rise of Corporate Capitalism* (New York: Alfred A. Knopf, 1977), on the role of engineers in the development of rational approaches to management.

5. Hughes, *American Genesis,* pp. 4 (quote), 7, 11–12. See, for example, Lewis Mumford, *Technics and Civilization* (New York: Harcourt, Brace and Company, 1934). F. E. Emery suggests that "the system" is associated with Western societies (Emery and E. L. Trist, *Towards a Social Ecology: Contextual Appreciation of the Future in the Present* [New York: Plenum Press, 1972], p. xii).

6. Noble, *America by Design,* pp. xvii, xxii.

7. Christopher Lasch, "Foreword," in Noble, *America by Design,* p. xii. Ida Hoos cites Wassily Leontief, who said essentially the same thing: "If something is not worth doing, it is not worth doing well" (*Systems Analysis in Public Policy* [Berkeley: University of California Press, 1972], p. 38). Variations on Boulding's comment were repeated often in interviews

with current members of the ISSS (formerly SGSR; at annual conferences in June–July 1994–1996), and the idea of suboptimization can be found in many of his writings. Donella Meadows also cites Boulding on this point in “Dancing with Systems,” *Whole Earth* (winter 2001): 62.

8. Lasch in Noble, *America by Design,* p. xiii. See Peter Galison, “The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision,” *Critical Inquiry* 21 (autumn 1994): 228–266; and Geof Bowker, “How to Be Universal: Some Cybernetic Strategies, 1943–1970,” *Social Studies of Science* 23 (1993): 107–127, for a discussion of the military origins of systems thinking. See discussions of the *Report from Iron Mountain,* an alleged secret government report on the necessity of war for the American economy, in Chapter 5 and Chapter 8.

9. Christopher Simpson, *Science of Coercion: Communication Research and Psychological Warfare, 1945–1960* (Oxford: Oxford University Press, 1994), pp. 3–4.

10. Claude Shannon and Warren Weaver, *The Mathematical Theory of Communication* (Urbana: University of Illinois Press, 1949), p. 116; Simpson, *Science of Coercion,* pp. 4–6, 8–9. Simpson cites S. Chaffee and John Hochheimer, “The Beginnings of Political Communications Research in the United States: Origins of the ‘Limited Effects’ Model,” in M. Gurevitch and Mark Levy, eds., *Mass Communications Yearbook,* vol. 5 (1985), p. 77. For further discussion of Weaver and information theory, see Chapter 4.

11. See Harold Smiddy and Lionel Naum, “Evolution of a ‘Science of Managing’ in America,” *Management Science* 1:1 (Oct. 1954): 1–31, for a discussion of the evolution of the field of management science. See also C. West Churchman and Richard O. Mason, eds., *World Modeling: A Dialogue* (Amsterdam: North-Holland Pub. Co., 1976) on linear programming.

12. See Robert Lilienfeld, *The Rise of Systems Theory: An Ideological Analysis* (New York: Wiley, 1978), pp. 103–104, on the origins of operations research; Daniel J. Kevles, *The Physicists: The History of a Scientific Community in Modern America* (New York: Knopf, 1978), for a discussion of radar research during World War II; and Ida Hoos, *Systems Analysis in Public Policy* (Berkeley: University of California Press, 1972), p. 20.

13. I have drawn most of my discussion of the fields of operations research and systems analysis from an interview with Dr. Linstone, on July 27, 1995, at the annual conference of the ISSS in Amsterdam. Linstone initiated a program in systems analysis at Portland State University. He became involved in the SGSR through West Churchman, who had also encouraged Russell Ackoff to join.

14. Linstone, personal interview. See also Mark Davidson, *Uncommon Sense: The Life and Thought of Ludwig von Bertalanffy (1902–1972), the Father of General System Theory* (Los Angeles: J. P. Tarcher, 1983), pp. 193–194, for a discussion of systems analysis at RAND.

15. I am indebted to Michael Warburton, who was involved in a number of research projects at IIASA, for background on its establishment. See Michael Thompson and Warburton, “Decision Making Under Contradictory Certainties: How to Save the Himilayas When You Can’t Find Out What’s Wrong with Them,” *Journal of Applied Systems Analysis* 12 (1985): 3–34.

16. Hoos, *Systems Analysis,* pp. 39–41. See also Hal Linstone, *The Challenge of the 21st Century: Managing Technology and Ourselves in a Shrinking World* (Albany: State University of New York Press, 1994); Hugh Miser and Edward Quade, *Handbook of Systems Analysis* (New York: North-Holland, 1985); and *The Journal of Technology Forecasting*. Hoos gives an excellent account of the tranference of systems analysis into other sectors of government. Linstone mentions Simon Ramo and Dean Wooldriege as key figures in the transfer of systems analysis from Bell Labs to Hughes Aircraft (personal interview, 1995).

17. Linstone, personal interview. See Jay Forrester, *Industrial Dynamics* (Cambridge, MA: MIT Press, 1961), *Urban Dynamics* (Cambridge, MA: MIT Press, 1969), and *World Dynamics* (Cambridge, MA: MIT Press, 1971).

18. John Von Neumann and Oskar Morgenstern, *Theory of Games and Economic Behavior* (Princeton: Princeton University Press, 1944); J. D. Williams, *The Compleat Strategyst* (New York: McGraw-Hill, 1966), pp. vii, 8. Von Neumann's first paper on game theory was published in 1928, but the first extensive account did not appear until 1944.

19. Williams, *The Compleat Strategyst,* pp. ix, 2–3, 12–13, 20–21.

20. George Richardson, *Feedback Thought in Social Science and Systems Theory* (Philadelphia: University of Pennsylvania Press, 1991), pp. 94–160. Using Richardson's categories, the work of Norbert Wiener and other participants in the Macy conferences is part of the cybernetic tradition, while Forrester is the primary theoretician of the servomechanistic tradition.

21. Richardson, *Feedback Thought,* pp. 97, 145, 148–149; Nic J.T.A. Kramer and Jacob de Smit, *Systems Thinking: Concepts and Notions* (Leiden, Netherlands: Martinus Nijhoff, 1977), p. 4. See Stafford Beer, *Cybernetics and Management* (New York: Wiley, 1959); C. West Churchman, Russell E. Ackoff, and Leonard Arnoff, *Introduction to Operations Research* (New York: Wiley, 1957); and Herbert Simon, *Models of Man, Social and Rational: Mathematical Essays on Rational Human Behavior in Society Setting* (New York: Wiley, 1957). Also Peter Checkland, *Systems Thinking, Systems Practice* (New York: Wiley, 1981), p. 16.

22. Richardson, *Feedback Thought,* pp. 145, 148; Simon, *Models of Man,* pp. ix–x, 1, 3. Simon cites Joseph Fourier, *The Analytical Theory of Heat* (Cambridge: Cambridge University Press, 1878).

23. Simon, *Models of Man,* pp. vii–viii, 2–3; Boulding, *The Organizational Revolution*.

24. Emery and Trist, *Towards a Social Ecology,* p. xv.

25. Checkland, *Systems Thinking,* pp. x, xii, 5, 10–18. Checkland echoes Alvin Gouldner, who argues that the rational and scientific elements of bureaucratic organization "remain encased within and limited by nonrational, nonscientific, political, and economic interests." While technological expertise can rationalize and legitimate the instrumental means used to achieve given organizational goals, the goals themselves can only be legitimated by value systems. In Gouldner, *The Dialectic of Ideology and Technology: The Origins, Grammar, and Future of Ideology* (New York: Seabury Press, 1976), p. 241.

26. Emery and Trist, *Towards a Social Ecology,* pp. ix–x, xiv–xv. They compare their work with that of Alvin Toffler in *Future Shock* (New York: Random House, 1970) and Donald Schon in *Beyond the Stable State* (London: Shaw & Temple, 1971). They also acknowledge their debt to Kurt Lewin's field-theoretical approach, from which, they write, "it was but a short step to develop a 'systems' orientation" (p. xiv).

27. Emery and Trist, *Towards a Social Ecology,* pp. xi–xiv. They cite David Riesman, "Leisure and Work in Post-Industrial Society," in E. Larrabee and R. Mayershon, eds., *Mass Leisure* (Glencoe, IL: Free Press, 1958); and Daniel Bell "Twelve Modes of Prediction," in J. Gould, ed., *Penguin Survey of the Social Sciences* (London: Penguin Books, 1965), in connection with the idea of the postindustrial society. Boulding also wrote extensively about what he called "post-civilization." See, for example, *The Meaning of the Twentieth Century* (New York: Harper, 1964).

28. Emery and Trist, *Towards a Social Ecology,* p. xiv.

FOUR

Cybernetics and Information Theory: Feedback and Homeostasis

> The subject matter of cybernetics is not events and objects but the *information* "carried" by events and objects. . . . Because the subject matter of cybernetics is the propositional or informational aspects of the events and objects in the natural world, this science is forced to procedures rather different from those of the other sciences. The differentiation between map and territory, which the semanticists insist that scientists shall respect in their writings, must, in cybernetics, be watched for in the very phenomena about which the scientist writes.
>
> —Gregory Bateson, *Steps to an Ecology of Mind*[1]

In association with the general evolution of systems engineering into management and organization theory described in the last chapter, the fields of cybernetics and information theory provided essential theoretical foundations for the further development of systems theory, in conjunction with the parallel emergence of computer technologies. Although an in-depth analysis of the technical aspects of these fields is beyond the scope of this study, what I hope to provide in this chapter is an overview of the many and varied interpretations of their significance for understanding the complex system of relationships within the human community and in its relationship to the natural environment.

When I first heard the term in the 1970s, I understood cybernetics as something vaguely connected with computers and artificial intelligence, an interpretation reinforced by the emergence of such contemporary concepts as cyberspace and cyborg. Cybernetics is perhaps most commonly associated with Norbert Wiener's work on self-correcting weapons systems, although the concepts of feedback and homeostasis that derived from Walter Cannon's work in physiology are at least equally significant, as are parallel developments in the social sciences, particularly in the work of cultural anthropologists Margaret Mead and Gregory Bateson.[2]

A 1942 conference on cerebral inhibition, bringing together researchers from the fields of computer science, neurophysiology, and the social sciences, led to a subsequent series of conferences between 1946 and 1953, sponsored by the Josiah

Macy Jr. Foundation. These cybernetics conferences focused on issues of circular causality and formed the foundation for later developments in a number of other fields, including artificial intelligence and cognitive science. According to James Miller, Robert Merton once commented that every sociologist had a file labeled "circles." Miller also suggested that cultural anthropology laid the foundations for functionalism in the social sciences, in its recognition that "everything is related to everything else" and that "the integration of the whole results from the interrelation of the parts."[3]

Wiener originally defined cybernetics as "control and communication in the animal and machine" and further described the field as a dramatic departure from the Newtonian world view and the basis for a tentative new theory of scientific method. As with Bertalanffy's open-system concept, the starting point for cybernetics grows out of the apparent contradiction between the second law of thermodynamics and the evidence of evolution. The second law states that the entropy or disorder in the universe is constantly increasing, which means that order is the least probable state of matter and chaos the most probable. As Wiener notes, however, there are enclaves within which there is a limited tendency for organization to increase. Life has continued to evolve increasingly complex and highly organized forms. He writes, "In control and communication we are always fighting nature's tendency to degrade the organized and to destroy the meaningful; the tendency for entropy to increase." And it is through communication, imparting organizing information to the system and its environment, that we are able to counter the tendency toward disorder: "The commands through which we exercise our control over our environment are a kind of information we impart to it."[4]

Of course, the language of command and control naturally evokes concerns about the implications of Wiener's work and of cybernetics in general. Despite the fact that Wiener himself became increasingly critical of the military after the war, the association between cybernetics and the war machine remains prominent among contemporary historians of science. Furthermore, cybernetics tends to be seen as primarily mechanistic and deterministic in its approach, despite its rootedness in the recognition of contingency and indeterminacy that came out of nineteenth-century work on statistics and probabilistic systems. Bertalanffy took great pains to distinguish his own approach from what he saw as the "machine view" of cybernetics, in its depiction of organisms as a "special class of machines that operate on engineering principles, particularly control by negative feedback," although in Europe the terms cybernetics and general systems theory were used more or less interchangeably.[5]

Nevertheless, in incorporating circular forms of causality and highlighting the importance of information and communication in the organization of complex systems, cybernetics moved beyond the linear causal modes of traditional mechanistic thought, opening the door for more recent discoveries in the chaotic dynamics of nonlinear systems. Further, as Steve Heims points out in his history of the Macy conferences, the most significant innovation emerging out of work in this field was the linking of the concepts of purpose and goal-directed activity across biological, technological, and social systems. While some object to the articulation of such concepts in mechanistic terms and others to the inclusion of such concepts in scientific discourse at all, the associated notions of feedback, communication, and control catalyzed further research on the interrelated nature of decisionmaking processes in these three types of systems.[6]

FEEDBACK: CONCEPTUAL ORIGINS

Although cybernetics emerged as a revolutionary concept in the 1940s and 1950s, examples of feedback processes can be seen in classical Greece—in Ktesibios's float valve in 250 B.C. and Heron's *Pneumatics* (60 A.D.) on fluid control mechanisms. In addition to such early techniques for regulating technical devices, George Richardson identifies roots of feedback thought in biology, logic, philosophy, social thought, and econometrics. These include ideas about homeostasis from biology, self-reinforcing and self-correcting phenomena from the social sciences, loop concepts from formal mathematics, as well as mathematical models of dynamic systems in biology, econometrics, and engineering. The term "cybernetics" is derived from a Greek word meaning governor or steering mechanism, reflected in the title of James Maxwell's 1868 paper "On Governors," which Richardson identifies as the first formal analysis of the structure and behavior of feedback devices. Maxwell's work was inspired by James Watts's steam engine and other eighteenth-century developments in automatic controls, which generated an increasing awareness of similar feedback processes in the behavior of individuals, groups, and societies.[7]

Richardson suggests that the concept of self-regulation was "part of the spirit of the times" in eighteenth-century Britain, shaping the development of social thought during that period. Both Adam Smith and David Hume incorporated concepts of equilibrium processes in their work. French mathematician and physicist André Ampère actually used the term "cybernetics" to describe the governing role in politics. And as Richardson notes, Alexander Hamilton's *Federalist Papers* reflects an effort to "design [government] so that its tendencies toward instability were countered by the form of government itself." In the essay he sent to Charles Darwin, Alfred Wallace wrote that natural selection operated as a kind of governor in the process of evolution, in what Richardson calls "the first unequivocal recognition of a connection between automatic control in engineering devices and self-regulation in living systems." These examples reflect a melding of concepts from the fields of technology, biology, and social thought similar to that which occurred two centuries later with the further refinement of the feedback concept in the field of cybernetics.[8]

CYBERNETICS: FEEDBACK IN THE TWENTIETH CENTURY

The single most important contribution to the evolution of cybernetics in the twentieth century was a paper coauthored by Arturo Rosenblueth, Norbert Wiener, and Julian Bigelow entitled "Behavior, Purpose, and Teleology." Wiener worked with Bigelow on military engineering projects, although his own work was probably more profoundly influenced by his association with Rosenbleuth, who worked closely with Cannon on homeostasis and regulating mechanisms in the central nervous system. The paper was initially presented at the 1942 conference on "Problems of Central Inhibition of the Nervous System" that laid the groundwork for the later series of conferences on cybernetics sponsored by the Macy Foundation. The authors addressed what they saw as the primary importance of the concept of purpose. They describe their approach to the study of natural events as behaviorist, examining the output of the object under study in relation to input from the environment. They contrast this approach with the functional approach, which tends to focus more on the intrinsic organization of the object, paying little attention to the relationship between the object and its environment. This distinction between external and internal relations is central in George Richardson's discussion of the two strands of feedback thought—cybernetics and servomechanism—that will be addressed later in the chapter.[9]

The paper then proceeds with a discussion of purposeful behavior, by which the authors meant behavior directed toward the attainment of a goal. Given this definition, some machines, which have been given the label of "servomechanisms," are seen to be intrinsically purposeful. Further, they suggest that all purposive behavior depends on negative feedback, that is, messages that inform the purposeful object of its deviation from its goal and help to direct its ongoing behavior. Early developments in cybernetics tended to emphasize such "negative" feedback, which might be more clearly defined as "deviation minimizing," that is, tending to maintain the stability of a system by correcting for deviations from a desired state. Thermostats as well as physiological mechanisms of self-regulation are examples of negative feedback. Only later did cybernetics begin to explore the significance of "positive" or "deviation amplifying" feedback that is responsible for change in a system, opening up possibilities for either evolutionary development or eventual breakdown.[10]

In a statement that has become the defining conception of cybernetics, Rosenbleuth and company conclude that this behaviorist analysis is applicable to both machines and living organisms and that broad classes of behavior in both kinds of systems can be described in the same terms. Although profoundly different at the functional level, they argue that these systems show no qualitative distinctions in behavioral processes. The authors acknowledge, however, that types of behavior may be limited by the nature of the receptors and internal organization of the object. By redefining teleology (or purposiveness) on the basis of behavioral similarities rather than in functional terms, as "purpose controlled by feedback," the authors pave the way for a mechanistic analysis of purpose, which can be understood independently of questions of causality. Critics, of course, objected to such a mechanistic conception of purposefulness.[11]

The ensuing conferences on cybernetics were focused specifically on the application of these concepts in understanding the role of feedback in the human nervous system. The authors suggest that the main purpose of the cerebellum is in controlling the feedback mechanisms involved in purposeful motor behavior. The second paper that was presented at the 1942 conference was by Warren McCulloch and Walter Pitts on the role of neural networks in purposive behavior, which had an equally profound impact on the further evolution of systems thinking, notably in the work of Anatol Rapoport. In contrast to the behaviorist orientation of the first paper, McCulloch and Pitts sought to understand the internal processes of the mind, further complicating tendencies to pigeonhole the overall development of the field. Equally important in this constellation of developments was the theory of information. In conjunction with emerging computer technology and communication networks, cybernetics highlighted the essential role of information in organization as well as the related dimensions of language, coding, and structure.[12]

INFORMATION AND COMMUNICATION THEORY

Leo Szilard's 1929 paper identifying information as a unique phenomenon, distinct from matter and energy, might be seen as ushering in the information era. Unlike matter and energy, information is not subject to the laws of conservation and can accumulate and grow over time, thus accounting for the triumph of evolution over entropy. Claude Shannon's mathematical formulation of information theory, published twenty years later in connection with his work at the Bell Telephone Research Laboratory, was concerned primarily with the technical problems of transmitting information through telephone lines. Significantly, as articulated in Shannon's theory, the concept of information is mathematically equivalent to negative entropy. His understanding of the nature of communication was heavily indebted to Wiener for much of its basic philosophy and theory.[13]

In his commentary on the significance of information theory, which accompanies Shannon's articulation of the theory itself, Warren Weaver discusses some of the broader implications of the information concept. According to Weaver, information could also be seen as a measure of the uncertainty and freedom of choice within the system. Conflating the technical and semantic dimensions of information, something that seems to happen with increasing frequency these days, he suggests that it would be possible to develop a "real theory of meaning" based on Shannon's elaboration of the physical nature of information. He acknowledges both physical and mental aspects of signals, distinguishing three areas of focus within the new field of information theory: the technical problem, the semantic problem, and the effectiveness problem, implying that all three can be addressed within the same mathematical framework. The problem of effectiveness relates to his definition of information as "the means by which one mind may influence another," once again fueling concerns about the tendency toward control inherent in these developments.[14]

Weaver points out that while Shannon was primarily interested in technical applications of these ideas, Wiener was actually more interested in their biological applications, especially in relation to the functioning of the central nervous system. In conjunction with information theory, cybernetics laid the groundwork for later work in artificial intelligence and cognitive science, integrating developments in computer technology with parallel developments in psychology and neurophysiology. Cybernetics thus emerges as a science of messages, lending itself as well to the study of social processes.[15]

Beyond electrical engineering and its limited concern with the technical transmission of messages, Wiener proposes "a larger field which includes not only the study of language, but the study of messages as a means of controlling machinery and society." It is messages that provide the pattern of organization in both animals and complex machinery. Unlike earlier automata, which functioned on a closed clockwork basis, Wiener notes that "modern automatic machines possess sense organs, that is, receptors for messages coming from the outside," and are thus conditioned by their relation to the external world: "For any machine subject to a varied external environment to act effectively it is necessary that information concerning the results of its own action be furnished to it as part of the information on which it must continue to act." It is the feedback nature of this process, where the actual performance of the machine forms the basis for further action, that is the fundamental conception of cybernetics.[16]

Wiener then applies this concept to an understanding of organization in society and suggests that communications are the cement that binds the fabric of society together and further that "society can only be understood through a study of the messages and the communication facilities which belong to it." The most controversial aspect of his theory is the idea that the study of communication and control can be applied to both animals and machines—that in the behavioral sense at least, there is no difference between them. Despite its somewhat mechanistic interpretation of human behavior, however, the emerging field of cybernetics served to highlight the importance of information and communication, the limitations of effectiveness inherent in the communication process, and the key role of perception, memory, and learning. In addition, it helped to clarify the relationship between information and decisionmaking processes in goal-oriented activities: "The process of receiving and of using information is the process of our adjusting to the contingencies of the outer environment, and of our living effectively within that environment."[17]

TWO STRANDS OF FEEDBACK THOUGHT

Richardson traces the emergence of the feedback concept in six separate fields—mathematical biology, econometrics, engineering, the social sciences, the biology of homeostasis, and logic (see Figure 4.1). He identifies two distinct approaches to incorporating feedback thought in the social sciences, which he refers to as the cybernetics and servomechanism threads. To some extent these threads can be associated with two distinct fields in engineering. The servomechanism thread is related to developments in control engineering, a well-established field with a long history, while the cybernetics thread is more closely related to the relatively new field of communications engineering, which was established in response to a whole new set of practical problems growing out of developments in communications technology.[18]

Richardson's own understanding of the feedback concept emerges out of his association with the systems dynamics community at MIT, the heart of the servomechanism tradition, which focuses on modeling complex systems using tech-

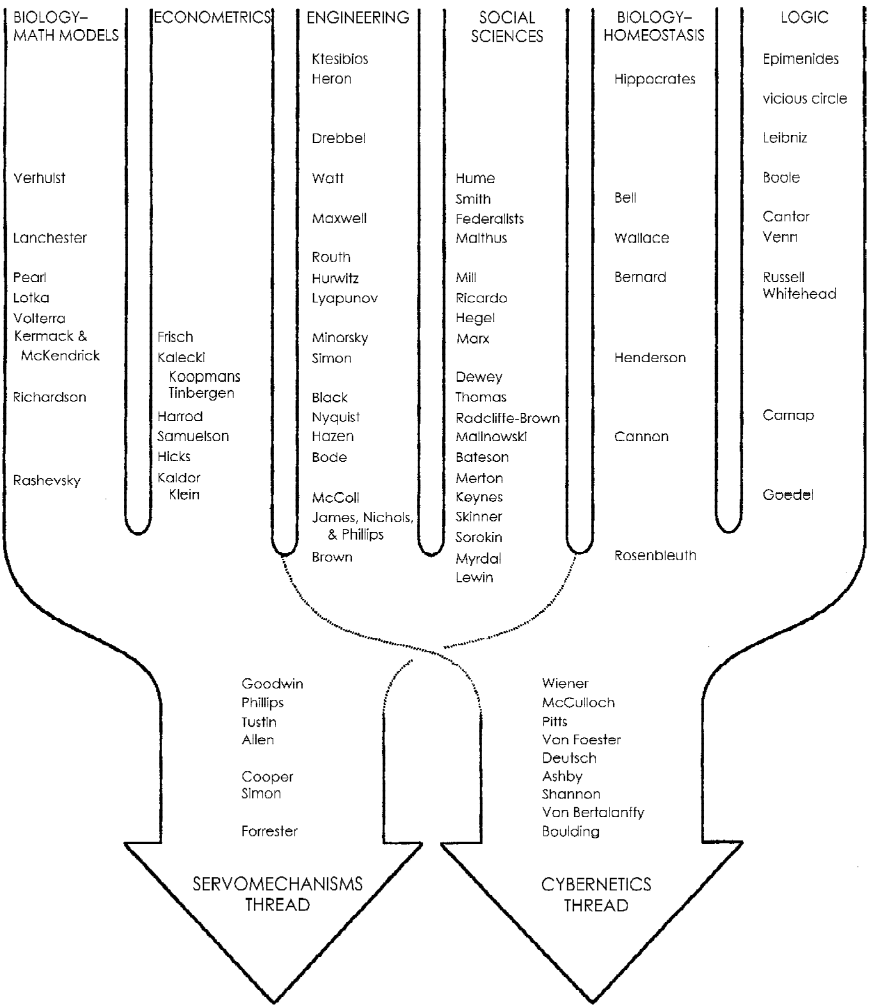


Figure 4.1. Sources of the Feedback Concept. Reproduced from George Richardson, *Feedback Thought in Social Science and Systems Theory* (Philadelphia: University of Pennsylvania Press, 1991), p. 93.

niques originally developed by Jay Forrester. Richardson's analysis of these two strands of feedback thought is helpful in clarifying some of the confusion that has arisen in connection with the concept, although I do not always agree with his characterizations of the cybernetic thread of social thought. Although the fields of control engineering and communications engineering were more or less combined during World War II, Richardson argues that they produced slightly different interpretations of the feedback concept. There is some potential for confusion here since Wiener, whom Richardson identifies as one of the primary theorists in the cybernetics strand, drew his inspiration from the field of control engineering in his work with self-correcting weapons systems during the war. Further, Richardson tends to minimize the mathematical dimension of GST, which he associates with the cybernetics strand, as well as its roots in mathematical biology and econometrics. However, his distinctions are useful in articulating the divergences between various conceptions of feedback processes.[19]

According to Richardson, the servomechanism strand is rooted in industry and economics. It was fully developed in the work of Jay Forrester, an electrical engineer in military systems research and management, whose work on industrial and urban dynamics formed the basis for *The Limits to Growth* (Meadows et al., 1972), a highly influential report sponsored by the Club of Rome, as well as the foundation for the emergence of the field of system dynamics. It was electrical networks, Richardson maintains, that highlighted the loop nature of the feedback process. While concepts of feedback and circular causality existed in both biology and the social sciences, he argues that they were not associated with the quantitative, statistical line of thinking common to engineering and economics. A notable exception is the mathematical models of predator/prey relationships, developed by Alfred Lotka and Vito Volterra, that he associates with the servomechanism strand. Of course, he fails to acknowledge the influence of Lotka's and Volterra's work on the development of Bertalanffy's conception of open systems, which is central to the evolution of the general-systems idea. According to Richardson, it was not until 1940 that mathematical models of feedback were applied in other fields.[20]

At least in the early years, the cybernetics strand tended to emphasize the role of negative feedback in correcting deviations from desired goals, while the servomechanism strand was more concerned with the interplay between positive and negative feedback that generates the dynamics of the behavior in any system. While negative feedback serves to minimize deviations from a fixed goal by responding to discrepancies between the actual state of the system and some desired state, positive feedback amplifies change away from established patterns of equilibrium. In attempting to understand the actual dynamics of a system, the servomechanism approach models the interaction between self-correcting and self-reinforcing aspects of the system's behavior using differential equations and computer simulation, providing a basis for heuristic analysis. It focuses on the internal causes of behavior, rather than on external means of manipulating behavior. Since nonlinear systems are capable of changing their active structure over time, Richardson argues that policies based on a linear understanding of system dynamics may create unexpected problems or exacerbate those they were intended to cure. Forrester's work in system dynamics was directed toward policy analysis to try to predict such dynamics. Table 4.1 illustrates the differences between the two strands as described by Richardson.[21]

In Richardson's interpretation, the cybernetics strand is oriented primarily toward controlling systems and emphasizes the external, regulatory nature of feed-

Table 4.1. Two Strands of Feedback Thought in the Social Sciences

Servomechanism	*Cybernetics*
Related to Control Engineering	Related to Communications Engineering
Emphasize Role of Feedback in Dynamic Behavior	Emphasize Role of Feedback in Communication and Control
Emphasize Structure of Internal Processes	Emphasize Behavior Black Box—Can't Know Internal Structure
Endogenous Look Inside System for Sources of Behavior	Exogenous Problems Caused by Forces External to System
Feedback as Intrinsic Part of Real System—Not Just Mechanism of Control	Feedback as Transmission of Information—Message Loops Related to Concepts of Self-Reference

Source: This table is derived from Richardson, *Feedback Thought,* pp. 15 (n. 3), 113, 116–118, 128–129, 140, 162–163.

back. It is more concerned with homeostasis and control than with understanding the intrinsic dynamic processes of a system. Richardson also suggests that it is characterized by a linguistic view of feedback, stressing the role of messages and symbols, unlike the servomechanism view that ignores the information content of feedback. In addition, cybernetics was most influenced by homeostatic models from biology as well as ideas from formal logic, tending toward a more theoretical and philosophical orientation, and relying less on mathematical models. Most importantly, it rejects the possibility of constructing realistic models of systems, and instead sees complex systems as "black boxes" of unknowable internal structure.[22]

However helpful these distinctions are in clarifying different views of feedback, Richardson's two categories break down when one looks carefully at the work of some of the different individuals he cites. Wiener and Ashby are the most important early sources in the cybernetics thread while Forrester's work is foundational in the servomechanism thread. Richardson suggests that few of the early feedback theorists drew from both traditions. Yet a number of current members of the general-systems community commonly mention all three as significant in their understanding of systems. While Richardson argues that the cybernetics strand did not use mathematical models, he does acknowledge that Ashby used mathematics, and Ashby's work has been identified by George Klir as the most significant influence in the evolution of the general-systems tradition. Although Richardson claims that the servomechanism strand was unique in its reliance on formal models, the search for formal similarities between different kinds of systems, at the heart of general systems theory, was based on the use of formal mathematical models (although the understanding of the feedback nature of these models might not have been quite as fully developed).[23]

Furthermore, as Richardson acknowledges, James Miller incorporates positive feedback into his "living systems" model, which was a central feature in the evolution of the general-systems approach. Boulding's concern with the dynamics of social systems also reflects elements of the servomechanism strand, as Richardson himself recognizes. Significantly, Bertalanffy made a similar distinction between the two forms of feedback, suggesting that the ecological equilibrium apparent in predator-prey relationships (the mathematical models in biology that Richardson associates with the servomechanism strand) is not the same thing as the feedback in cybernetics associated with control and regulation. Bertalanffy constantly distinguished his view of general systems theory from cybernetics because of his emphasis on the dynamic interactions within a system and his rejection of what he saw as the machine theory of feedback inherent in the latter. Karl Deutsch, whom Richardson also identifies with the cybernetics strand, points to the need for a model of organization in machines, minds, and societies that understands these systems as *self-modifying* networks to replace the older mechanistic and organismic views.[24]

CYBERNETICS AND SOCIAL THEORY

The distinction between these two views of feedback is central to the project of clarifying its social implications. What Richardson describes as the cybernetics strand clearly lends itself more easily to manipulative models of social control. Weaver's definition of communication as "the means by which one mind may influence another" reinforces this view, echoing Christopher Simpson's interpretation of the predominant orientation in communication studies during the postwar period.[25]

Even the servomechanism approach, despite its focus on internal dynamics, is used primarily to analyze potential consequences of different *interventions* in the dynamics of specific systems. And what Richardson describes as the antimechanistic and antibehaviorist orientation of the servomechanistic emphasis on internal dynamics is echoed in Bertalanffy's elaboration of general systems theory. In conjunction with parallel developments relating to self-organizing systems, his "humanistic" orientation provides a starting point for participatory models of decisionmaking in social systems.[26]

Critics of the application of feedback concepts in ecology and social thought focus on what they see as the fundamental conservatism of the equilibrium models that characterize the cybernetics strand of feedback thought. Addressing the work of Eugene and Howard Odum in systems ecology, for example, Peter Taylor argues that the cybernetic theory of feedback mechanisms reinforces a machine view of nature and legitimizes the scientific management of society: "A social feedback system implied the existence of systems scientists under whose controlling hands the system would run for the benefit of the rest of society." Another aspect of Taylor's critique is the fundamental reductionism of the Odums' approach. In reducing ecological complexity to energetic terms, Taylor sees systems ecology as aspiring to the theoretical status of the physical sciences, echoing Donna Haraway's suggestion that "information is just that kind of quantifiable element which allows universal translation and so unhindered instrumental power."[27]

For many in the general-systems community, however, the concepts of feedback and information provided the key to democratic forms of social organization. With the emergence of the concept of second-order cybernetics, which emphasized the self-reflexive nature of feedback processes in the evolution of human consciousness and the increasing significance of symbolic systems, cybernetic approaches to management in the general-systems tradition sought to incorporate feedback from all members of the system in the design and management of social, political, and economic systems. This orientation forms the foundation of work in the "soft" systems tradition and is reflected in the work of Russell Ackoff, Stafford Beer, and Peter Checkland, to be discussed in greater depth in Chapter 9.[28]

NOTES

1. Gregory Bateson, *Steps to an Ecology of Mind* (New York: Ballantine, 1972), pp. 401–402 (emphasis in original).

2. See Steve Heims, *Constructing a Social Science for Postwar America: The Cybernetics Group, 1946–1953* (Cambridge, MA: MIT Press, 1991), on the role of Mead and Bateson in the evolution of cybernetics. See Peter Galison, "The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision," *Critical Inquiry* 21 (autumn 1994): 228–266; and Geof Bowker, "How to Be Universal: Some Cybernetic Strategies," *Social Studies of Science* 23 (1993): 107–127, for discussions of the relationship between Wiener, cybernetics, and the military.

3. Miller, personal interview, 1995. See Heims, *Constructing a Social Science,* for an excellent history of the Macy conferences; as well as the proceedings of the conferences, compiled in Heinz von Foerster, ed., *Cybernetics: Circular Causal and Feedback Mechanisms in Biological and Social Systems* (New York: Macy Foundation, 1952). Of the founders of the SGSR, Ralph Gerard was the only one who attended the Macy conferences.

4. Norbert Wiener, *Cybernetics: Or Control and Communication in the Animal and the Machine* (Cambridge, MA: MIT Press, 1948) and *Human Use of Human Beings: Cybernetics and Society* (New York: Avon Books, 1967/1950), pp. 13–15, 18, 20–23, 26. Wiener acknowledges the influence of Josiah Willard Gibbs, whose ideas on systems were influential in the development of social-systems theories, especially in the work of Vilfredo Pareto, Lawrence Henderson, and Talcott Parsons (see Chapter 5).

5. James Miller and Jessie L. Miller, "Cybernetics, General Systems Theory, and Living Systems Theory," in Ralph L. Levine and Hiram E. Fitzgerald, eds., *Analysis of Dynamic Psychological Systems,* Vol. 1: *Basic Approaches to General Systems, Dynamic Systems, and Cybernetics* (New York: Plenum Press, 1992), pp. 9–10. See Galison, "Ontology of the Enemy," and Bowker, "How to Be Universal," for examples of the tendency to focus on the military aspects of Wiener's work.

6. Heims, *Constructing a Social Science,* pp. 9, 12–15; D. C. Phillips, *Holistic Thought in Social Science* (Stanford, CA: Stanford University Press, 1976), p. 59; Pitirim Sorokin, *Sociological Theories of Today* (New York: Arno Press, 1979), p. 62.

7. George Richardson, *Feedback Thought in Social Science and Systems Theory* (Philadelphia: University of Pennsylvania Press, 1991), pp. 17–21, 23, 32 (reprinted Waltham, MA: Pegasus Communications, 1999). Richardson cites Otto Mayr, *The Origins of Feedback Control* (Cambridge, MA: MIT Press, 1970); also James Clerk Maxwell, "On Governors," *Proceedings of the Royal Society of London* 16 (1868): 270–283.

8. Richardson, *Feedback Thought,* pp. 59, 64–65, 70, 133. See David Hume, "On the Balance of Trade" (1752), in T. H. Green and T. H. Grose, eds., *Essays Moral, Political, and*

Literary (London: Longmans, Green, and Co., 1898); and Adam Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations* (London: W. Strahan and T. Cadell, 1776); also Wiener, *Human Use of Human Beings*, pp. 23–24, on Ampère; and Bateson, *Steps to an Ecology of Mind,* p. 428, on Wallace's letter to Darwin.

9. Arturo Rosenbleuth, Norbert Wiener, and Julian Bigelow, "Behavior, Purpose, and Teleology," in Walter Buckley, ed., *Modern Systems Research for the Behavioral Scientist: A Sourcebook* (Chicago: Aldine, 1968), p. 221, originally published in *Philosophy of Science* 10 (1943): 18–24. While this paper was the most influential, it was not the first to introduce the feedback concept. W. Ross Ashby wrote a paper in 1940, "Adaptiveness and Equilibrium," *Journal of Mental Science* 86 (1940): 478–483, introducing the concept of the "functional circuit," and describing adaptive behavior as "goal seeking." Like Talcott Parsons, who incorporated cybernetics concepts in his "social systems theory," Ashby emphasized the importance of stable equilibrium in adaptive behavior. See Heims, *Constructing a Social Science,* p. 17; Miller and Miller, "Cybernetics," p. 10; W. Ross Ashby, *Design for a Brain* (New York: Wiley, 1952) and *An Introduction to Cybernetics* (New York: Wiley, 1956).

10. See Magoroh Maruyama, "The Second Cybernetics: Deviation-Amplifying Mutual Causal Processes," *American Scientist* 51 (1963): 164–179, for an early discussion of positive feedback in the cybernetics tradition.

11. Rosenbleuth, Weiner, and Bigelow, "Behavior, Purpose, and Teleology," pp. 222–225 (quote p. 225). See also Richard Taylor, "Comments on a Mechanistic Conception of Purposefulness," in Walter Buckley, ed., *Modern Systems Research for the Behavioral Scientist* (Chicago: Aldine, 1968), pp. 226–231.

12. Richardson, *Feedback Thought,* pp. 52, 95–99; Rosenblueth, Weiner, and Bigelow, "Behavior, Purpose, and Teleology," p. 223; and Warren McCulloch and Walter Pitts, "A Logical Calculus of the Ideas Immanent in Nervous Activity," *The Bulletin of Mathematical Biophysics* 5 (1943): 115–133.

13. Leo Szilard, "Über die Entropieverminderung in einem thermodynamischen System bei Eingriffen intelligenter Wesen," *Zeitschrift fur Physik* 53 (1929); Claude Shannon and Warren Weaver, *The Mathematical Theory of Communication* (Urbana: University of Illinois Press, 1949).

14. Shannon and Weaver, *The Mathematical Theory of Communication,* pp. 52, 95–96, 100, 103–104. Weaver was the director of the Natural Science Division (1932–1955) and later vice president (1955–1959) of the Rockefeller Foundation. He comments on the inverse relationship between information and entropy, which has become somewhat controversial, although at the time it seemed to highlight the central role of information in overcoming the limitations imposed by the second law of thermodynamics. See Richardson, *Feedback Thought,* pp. 99, 105, for a discussion of McCulloch's and Wiener's perspectives on the relationship between information and entropy.

15. Shannon and Weaver, *The Mathematical Theory of Communication,* p. 116.

16. Wiener, *Human Use of Human Beings,* pp. 23, 33–36. Wiener's examples of "modern machines" include "the controlled missile, the proximity fuse, the automatic door opener, the control apparatus for a chemical factory, and the rest of the modern armory of automatic machines which perform military or industrial functions."

17. Ibid., pp. 25–27. See also Richardson, *Feedback Thought,* p. 102.

18. Richardson, *Feedback Thought,* p. 163.

19. Ibid., pp. 163–164.

20. Ibid., pp. 17, 46, 162. See Jay Forrester, *Industrial Dynamics* (Cambridge, MA: MIT Press, 1961), *Urban Dynamics* (Cambridge, MA: MIT Press, 1969), and *World Dynamics* (Cambridge, MA: MIT Press, 1971); Donella Meadows, Dennis Meadows, J. Randers,

and W. W. Behrens, *The Limits to Growth* (New York: University Books, 1972); and Alfred Lotka, *Elements of Mathematical Biology* (New York: Dover, 1956/1925). I am also indebted to Irving Elichirigoity's discussion of Forrester's work in an unpublished chapter entitled "Jay Forrester and the Construction of System Dynamics."

21. Richardson, *Feedback Thought,* pp. 4–5, 15 (n. 3), 38, 129, 134–140.

22. Ibid., pp. 1, 17, 116–118, 162, 326–331. Other references to positive feedback among those identified with the cybernetics strand include Gregory Bateson's concept of "schismogenesis," or runaway positive feedback, in social interactions (see Heims, *Constructing a Social Science,* p. 59); and Maruyama, "The Second Cybernetics," pp. 164–179.

23. Richardson, *Feedback Thought,* pp. 11, 112. See George Klir and Gary Rogers, eds., *Basic and Applied General Systems Research: A Bibliography* (Binghamton: State University of New York Press, 1977), pp. iv–v, for a discussion of Ashby's influence in the general-systems community. In response to this chapter, Richardson argued that, although theorists in the cybernetics thread may have been influenced by mathematical models, their discussions of the influence of feedback in social contexts tended to rely on verbal description rather than mathematical analysis.

24. Richardson, *Feedback Thought,* pp. 100, 121–123, 126–127. Bertalanffy distinguished his theory of open systems, based on dynamic interactions, from the cybernetic view that he claims was based on structural arrangements. Richardson suggests that Bertalanffy might have confused the notion of closed causal loops with his understanding of closed systems.

25. See Christopher Simpson, *Science of Coercion: Communication Research and Psychological Warfare, 1945–1960* (Oxford: Oxford University Press, 1994), for a discussion of the communication field, specifically in connection with advertising and propaganda.

26. See Donella Meadows, "Places to Intervene in a System," *Whole Earth* (winter 1997): 78–84, for an example of the emphasis on intervention in the servomechanist tradition. Meadows is one of the authors of *Limits to Growth,* as well as the more recent *Beyond the Limits: Confronting Global Collapse, Envisioning a Sustainable Future* (Post Mills, VT: Chelsea Green, 1992), and is well-known for her work in the sustainability movement.

27. Heims, *Constructing a Social Science,* p. 9; and Peter Taylor, "Technocratic Optimism, H. T. Odum, and the Partial Transformation of Ecological Metaphor After World War II," *Journal of the History of Biology* 21:2 (summer 1988): 223, 234, 237. See also Peter Taylor, "Ecosystems as Circuits: Diagrams and the Limits of Physical Analogies," *Biology and Philosophy* 6:2 (April 1991): 277, 282; and Donna Haraway, *Simians, Cyborgs, and Women: The Reinvention of Nature* (New York: Routledge, 1991), p. 164.

28. See Heinz von Foerster, ed., *Cybernetics of Cybernetics: The Control of Control and the Communication of Communication* (Urbana: Biological Computer Laboratory, University of Illinois, 1974), for his introduction of the concept of second-order cybernetics.

FIVE
Ecology and Social Theory: Structure, Function, and Evolution

> The psychosocial aspects of man, his meaningful behavior and the meaningful aspects of social and cultural phenomena cannot be caught in the cybernetic net.
>
> —Pitirim Sorokin, *Sociological Theories of Today*[1]

> An ecological model can be twisted into a highly institutionalized and status-quo-oriented approach that negates the essence of ecology, [which is] change, and the participation of all segments of a system in the processes through which that change occurs. . . . Treated as an open system, an ecological model for social planning can actually help ensure the survival of democratic procedures.
>
> —Len Duhl, on the *Report from Iron Mountain*[2]

In my quest for alternatives to the mechanistic paradigm, I was generally attracted to the idea of holism, which I associated with such perspectives as holistic medicine and the kind of ecological holism implicit in the "whole earth" photograph taken from space—an archetypal symbol of the evolutionary process of systemic self-reflection and, perhaps, self-transcendence. As I began to explore the implications of holistic perspectives in the social sciences, I could appreciate concerns about the potential tendency toward social control implicit in such views and the failure of such perspectives to account for the inner, subjective dimension of human experience that Sorokin identifies. On the other hand, it seemed to me that there might be other ways of conceiving social systems in holistic terms that would highlight interdependence and facilitate collaborative and inclusive approaches to social planning and organization, as Len Duhl suggests in connection with the idea of open systems.

Because of the normative element implicit in both fields, applications of organismic, cybernetic, and systems concepts in the ecological and social sciences are by far the most controversial. In addition, prejudices stemming from interpretations of the implications of such concepts in these macro realms often color interpretations of their significance in other fields. Ecology is a relatively new field, emerging as an established discipline in the early to mid-twentieth century, although it is rooted in much earlier observations on the "economy of nature." As one of the first economists to incorporate ecological perspectives in his work, Kenneth Boulding often referred to economics as the second oldest science. In fact, Adam Smith's description of the mechanisms of the marketplace was heavily indebted to the mechanical laws of Newtonian physics, the foundational science of the modern era.[3]

Darwin's theory of evolution, itself inspired by the individualistic orientation of Smith's model, established biology as the archetypal science of the nineteenth century and highlighted the importance of understanding the relationship between the organism and the environment. Ernst Haeckel, a German biologist who became one of Darwin's strongest advocates, actually coined the term "ecology" in 1866 to refer to the study of such relationships. Darwin's work also inspired developments in the new field of sociology, which emerged in the late nineteenth century in response to the dramatic social changes brought about by the industrial revolution. This is particularly evident in the work of Herbert Spencer, who is responsible for the phrase "the survival of the fittest," which is generally (and mistakenly) attributed to Darwin. Further illustrating the interrelationship between developments in these various fields, Sharon Kingsland points out that Spencer was trained as an engineer and conceived of nature in self-regulating terms, as a moving equilibrium between opposing forces.[4]

Ecological communities and human societies were both understood in organismic terms in the 1920s and 1930s, with a parallel transition to systems concepts taking place in the 1940s and 1950s. One of the most influential ecologists during the early period was Frederic Clements, whose concepts of ecological succession and the climax community were rooted in Spencer's organismic sociology. Arthur Tansley introduced the concept of the ecosystem in 1935, and G. Evelyn Hutchinson, a participant in the Macy conferences on cybernetics, introduced feedback concepts into ecology, contributing to the articulation of systems ecology in the work of Eugene and Howard Odum. Rooted initially in Spencer's work, organismic models in sociology also evolved to encompass developments in cybernetics, particularly in connection with Walter Cannon's work on feedback and homeostasis, which provided the foundation for Talcott Parsons's social-systems theory.

The tendency to see the shift from organismic to systems concepts as a shift from organic to mechanistic metaphor is an oversimplification of the variety of syntheses resulting from the integration of organismic, cybernetic, and systems concepts in different contexts. Some interpretations emphasized the similarities, or isomorphic relationships, between systems at different levels of organization. Others emphasized the phenomenon of emergence, underscoring the unique and irreducible properties that emerge at higher levels. This distinction can be seen in comparing the work of James Grier Miller, whose living-systems model focuses primarily on structural and functional similarities in different kinds of systems, with that of Boulding, whose model of nine different system levels highlights the increasing significance of language, perception, and values at the level of the social system.

Another difference has to do with the relative emphasis on equilibrium or change. Peter Taylor argues that equilibrial formulations "show no history or prospect for change," and that organicist or functionalist approaches in ecological and social sciences tended to emphasize such concepts as adaptation, adjustment, and integration. While he acknowledges that early systems theorists perceived their science to be antitechnocratic, allowing for the creation of systems that would be responsive to the needs of interacting individuals, he argues that this potential was ultimately betrayed in the cybernetic conception of communication as an instrument of control.[5]

A further issue distinguishing various holistic models in the social sciences relates to the degree of integration that is presumed to exist between the individual and the community, whether the social order is conceived in unitary or pluralistic terms and whether individualistic or collectivist concerns are in the forefront. The general-systems tradition, rooted as it was in the behavioral sciences, was very much influenced by the newly emerging field of social psychology, which sought to bridge individualist and collectivist conceptions of society and to come to terms with the respective roles of structure and agency. Within the general-systems group, one finds a spectrum of approaches, many of which reflect positions quite distinct from the "social systems theory" of Talcott Parsons that many in social-science fields identify with systems thinking.

THE EVOLUTION OF ECOLOGY

The systems view in ecology emerged out of organismic models that were prevalent in both biological and social sciences during the early twentieth century. Sharon Kingsland defines ecology as the study of patterns in nature, concerned with how interactions between populations of organisms and their environments give rise to larger patterns of communities and ecosystems. In its focus on the relationships between organisms and their environment, ecology occupies a somewhat ambiguous position in the borderland between the biological and social sciences, and historically there has been a strong connection between ecological and social concepts. In the latter half of the twentieth century, however, the social dimension of ecology has been steadily eclipsed as the field has struggled to define itself as a natural (or "real") science.[6]

Gregg Mitman identifies a growing division between ecology more narrowly defined as a science and ecology as the basis for conservation and the environmental movement, which might be seen as a tension between the descriptive and normative elements of the field. More than any other science, ecology lends itself to normative interpretations, which Mitman suggests have traditionally fallen into two categories, one supporting alignment with the presumed inherent balance of nature, and the other supporting a more managerial, interventionist view. Anna Bramwell acknowledges these two divergent trends in her description of ecology as an uneasy synthesis of antimechanistic, holistic biology, on the one hand, and energy economics on the other. The emergence of chaos theories in the 1980s transcends the boundaries of Mitman's categories, with the recognition of chaotic dynamics in nature as well as the inability to predict the consequences of human intervention.[7]

Organismic conceptions of ecology tended to emphasize the symbiotic nature of competition in the natural world, contributing to the rise of conservationist views in the early twentieth century. Clements's study of plant associations provided an important theoretical model of nature, known as the historical or dynamic school, that dominated American ecology from the 1920s through the 1940s. In its emphasis on the inherent balance of nature, his concept of ecological succession, along with his model of the climax community, challenged the ethic of unrestrained individualism and technological mastery of the environment. It reinforced a strong respect for the relative stability of the natural order, in accord with the holistic currents emerging in biology during the early twentieth century.[8]

In his history of the "Chicago School" of ecology, which focused primarily on studies of animal behavior, Mitman discusses their emphasis on cooperation and group selection as the most significant factors in the adaptation of organisms to their environment. The Chicago ecologists saw cooperation as essential to the survival of the whole, which in turn would ensure the welfare of the individual parts. In general, however, the group tended to define cooperation in terms of patterns of dominance and hierarchy, justifying social control and the subordination of the individual in a hierarchical division of labor. On the other hand, Clyde Allee had a different orientation from other members of the group. Like Boulding, he was a Quaker, and his belief in nonviolence shaped his preference for nonhierarchical models of cooperation and patterns of integration that were not based on dominance.[9]

Ralph Gerard was closely associated with the Chicago school, and his extensive writings on issues of science and ethics reflect a definite orientation toward social control: "If it is at all ethical to manipulate the universe, it is ethical to learn how and actually to manipulate its human components." William Morton Wheeler's concept of the superorganism, a central feature in Gerard's work, provides a link between the Chicago ecologists and the group that Michael Ghiselin refers to as the "Harvard crypto-vitalists" (including Whitehead, Cannon, and Henderson). Ghiselin argues that their holistic philosophy and the corresponding emphasis on cooperation assumes a level of integration that simply does not exist in the natural world, governed as it is by Darwinian principles of natural selection. As Ghiselin puts it, "The economy of nature is competitive from beginning to end." In the context of the postwar era, organismic holism came to be increasingly associated with totalitarian regimes and the subordination of the individual to the state, and cooperative organismic models in ecology gave way to more competitive economic models.[10]

The most important challenges to Clements's climax model came from Herbert Gleason and Arthur Tansley. While Clements focused on the plant community as an integrated whole, Gleason described the plant community as a collection of independent individuals, and Tansley portrayed plants, animals, and the physical environment together as components of an ecological "system," integrating physical and mechanistic concepts in his model of ecological interaction. Tansley introduced the ecosystem concept in 1935, in reaction to the organismic holism of community ecology, although it did not appear in ecology textbooks for another ten years. Despite his somewhat mechanistic and reductionist orientation, Tansley's model was more inclusive than Clements's approach, incorporating the inorganic components of the environment into the purview of ecology. In attempting to isolate and quantify the basic units of nature, he focused on the exchange of energy and chemical substances, leading to an economic model of the environment in which plants and animals came to be seen as producers and consumers.[11]

The field of systems ecology was further developed by Eugene and Howard Odum, building on the work of Evelyn Hutchinson and Raymond Lindeman that incorporated ideas about feedback from cybernetics and information theory into Tansley's ecosystem model. As systems ecology evolved, with its emphasis on energy flows, it became increasingly mechanistic. In understanding the coordinating forces in ecology in terms of economic conceptions of the free market, it was oriented primarily toward the rational management of the relationship between human and natural systems, and has often been associated with the intensification of managerial capitalism during the postwar era. Peter Taylor, for example, argues that the cybernetic theory of feedback mechanisms reinforces a machine view of nature, and, further, that the idea that nature is decomposable into systems implies that the systems analyst has a privileged vantage point external to the system, from which s/he is able to manage and control it.[12]

A number of writers portray systems ecology as a movement that fostered a more rationalistic approach to the management of nature. Frank Golley suggests that the ecosystem concept was more popular in the United States than in Europe, where its association with prewar organismic theories of ecological and social organization made it more suspect. In the United States it was associated with systems, information theory, computers, and modeling, reinforcing a more mechanistic theory of the state. In this context, it promised insights into the dynamics of complex systems and guidelines for managing the environment. However, in simplifying complex systems to only a few components, it reinforced an overly simplistic and somewhat deterministic view of natural and social organization.[13]

On the other hand, the ecosystem concept did foster a more holistic point of view, providing a kind of synthesis between the machine metaphor and the organismic concern with whole systems through its focus on relationships and interconnectedness. To some extent, the ecosystem model transcends the deterministic orientation of earlier organismic models, which reinforced notions of goal-directedness and self-regulation, and instead reflects a more postmodern view of the world as dynamic, contingent, and ever changing. Like Clements's model of the plant community, though, the ecosystem concept continued to stimulate inquiry into deeper questions about how humans should live with each other and the environment, providing support for the budding environmental movement. Perhaps more than in any other field, this divergence between the applications and implications of systems ecology illustrates the paradoxical relationship between holistic/ecological and technocratic elements in the systems approach.[14]

Ecology in the academies gradually shifted away from large systems and began to focus more narrowly on the population studies of evolutionary ecology.

While helpful in the analysis of the interactions among different species, population ecology did not really concern itself with the physical environment. This approach is rooted in the mathematical models of population dynamics, developed originally by Alfred Lotka and Vito Volterra, that were influential in the development of Ludwig von Bertalanffy's open-system concept. It is worth noting that both systems ecology and population ecology incorporated equilibrium models, the first in terms of energy, and the second in terms of populations. Sharon Kingsland points out the difficulty of integrating theoretical, experimental, and field approaches in ecology. While mathematical models might be able to represent the phenomena of growth, predation, and competition, she suggests that the ahistorical orientation of mathematical thinking was foreign to the traditional patterns of ecological thought. Nevertheless, contemporary ecologists have increasingly turned to systems concepts, information theory, mathematical programming, and game theory in their efforts to formulate a predictive ecology and to facilitate the management and control of nature. In the process, Kingsland suggests, they have often ignored history in favor of the unifying concepts provided by an equilibrium view of nature.[15]

Drawing on hierarchical concepts from systems theory, the work of Timothy Allen and Thomas Hoekstra reflects recent developments in the systems ecology tradition. They argue that efforts to increase detail and rigor in the mathematization of ecological systems are not appropriate when dealing with "significantly complex systems." They describe a process of "complex systems analysis," based on a hierarchy of levels, including cells, organisms, populations, communities, ecosystems, landscapes, biomes, and the biosphere that entails a consideration of interlevel relationships in both directions. To understand a phenomenon at any level of organization, it is necessary to examine both the higher levels, in order to understand the context, and the lower levels, in order to understand the mechanisms involved. Contrary to many interpretations of systems approaches, this approach does not privilege either top-down or bottom-up models of causality. In addition, like most of the general-systems community, Allen and Hoekstra acknowledge the importance of recognizing the role of the observer in the system. Further, they suggest that their approach does not rely on the assumption that the ecological entities so defined (i.e., landscapes, biomes, etc.) are real, concrete systems, but rather that they provide a tool to facilitate the study of ecology in organizing and challenging perception.[16]

Such a task is both particularly difficult and critical, since ecological concerns impinge directly on human society. Beyond the quantifiable elements of ecosystems and populations are qualitative and normative aspects that cannot be adequately addressed through science alone. It is the suppression of these value-laden aspects of the science that critics of the systems approach address. In his discussion of Howard Odum's social and ecological prescriptions, based on his energy-exchange model of ecology, Peter Taylor argues that "large-scale reduction of complex social phenomena to simple quantitative variables exemplified one of the besetting vices that Lilienfeld has identified with systems thinking." Boulding himself was critical of this reduction of ecological issues to energetic terms as well as the failure to consider human values. In a review of Odum's *Energy Basis for Man and Nature,* Boulding writes, "Ecologists, like many economists, have been obsessed by equilibrium. The real world, however, is an evolutionary, that is disequilibrium, system, and crude equilibrium models of energy flows are only a first step toward understanding it."[17]

Certainly, from its inception, ecology has lent itself to ideologies of control, whether as an instrument of radical politics or of technocratic management. Alternatively, ecology might be seen as a way of looking at the world that focuses on interrelationships and fosters a kind of inclusive epistemology. In the quotation at the beginning of this chapter, Leonard Duhl, who was closely associated with the founders of the general-systems society, builds on Bertalanffy's conception of open systems in discussing the political implications of ecology. Like Taylor, he is critical of models that portray ecological systems as closed and rigid systems, which could be used as an excuse for massive control. At the same time, however, he suggests that ecological models might also highlight the importance of considering all elements of a system, and in the case of social systems including all members in the decisionmaking process.

Ecological interpretations of the natural order provide a foundation for concepts of social unity and order in terms of interacting organisms and their environment. As Joel Hagen points out, nature has been variously portrayed as a "battlefield" and as a "stable complex of interacting parts," echoing the ambiguous relationship between competition and social stability in Herbert Spencer's concept of the social organism. Kingsland notes that Lotka reflected early-twentieth-century trends in social theory in his search for a more holistic vision of the relationship between humans and nature. Unlike Spencer, however, he saw humans as active participants in an interconnected cosmos. The idea of a dynamically unified nature challenged scientists to discover the laws that governed that unity. Kingsland suggests that early ecologists sought to create a synthetic discipline that would include humans in the study of nature, bridging the boundaries between natural science and the emerging social sciences.[18]

While ecology as the science of relationships between organisms and their environments should naturally include human organisms, by the mid-twentieth century most ecologists were no longer interested in human ecology. Eugene Cittadino attributes this to the disdain among natural scientists for the social sciences. However, ecological concepts were gradually integrated into the theoretical frameworks of the social sciences, as the impacts of human intervention in natural processes became increasingly problematic. In addition, an "ecological approach" in these fields came to mean taking into account a larger framework. In economics, for example, it meant taking into consideration social, political, psychological, and other components of human interaction.[19]

The concept of human ecology became associated with the work of sociologists Robert Park and Ernest Burgess at the University of Chicago in the early 1900s. Park, in particular, had a tremendous influence on Boulding's articulation of

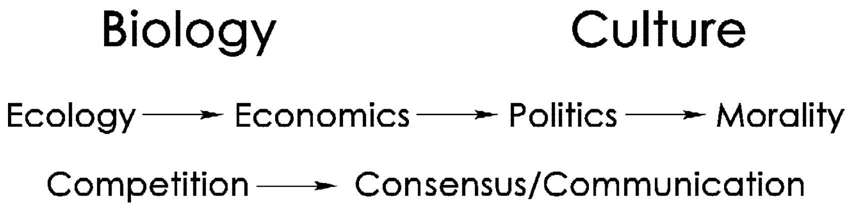


Figure 5.1. Robert Park on Human Ecology

an ecological economics. Given the parallel significance of the Chicago school of ecology in the evolution of general-systems ideas, particularly in connection with Gerard's organismic views, it is noteworthy that there was very little interaction between ecologists and sociologists at Chicago. For Park, as for H. G. Wells, who had proposed a more ecological approach to the study of human society, ecology was simply economics extended to the whole of life, and an ecological conception of society was rooted in what was seen as the competitive symbiosis of the free-enterprise system. The same idea was expressed a generation earlier by Lester Ward, who extended the biological idea of symbiosis into a universal principle of synergy, which he defined as "the systematic and organic working together of the antithetical forces of nature."[20]

Park, however, drew a sharp distinction between the biological and cultural aspects of human society, the latter of which included both customs and beliefs as well as artifacts and technology. Although the biological and social spheres interacted, he argues that they were governed by different principles. Acknowledging the important role played by media technologies in society, Park described a progressive shift from competition to communication and consensus moving across the spectrum from ecology to economics, politics, and morality (see Figure 5.1).

Park saw competition as the predominant characteristic of the ecological level, with the individual becoming increasingly incorporated into and subordinated to the social order on each of the succeeding levels. Although he recognized that the competitive nature of the ecological realm had an important role in shaping human behavior, his study of news media exemplified his concern with the integrative role of communication at the cultural level, anticipating later trends in social theory. However, unlike most organicist and functionalist sociologists of the 1940s and 1950s, he emphasized process over structure, describing both the natural environment and society as systems in dynamic disequilibrium.[21]

PERSPECTIVES ON SOCIAL THEORY

In his survey of sociological thought, Lewis Coser suggests that the Chicago school, drawing from the work of Park and Burgess, as well as that of John Dewey and George Herbert Mead, was dominant in American sociology until around 1935, at which time the Parsonian synthesis of European social thought came to the forefront, and remained the dominant framework into the 1960s. Although Park and Burgess had drawn from European theoretical frameworks, they tended more toward an atheoretical empiricism, and Parson's work provided a much more systematic synthesis. This shift away from empiricism toward a more theoretical orientation parallels the rise of the behavioral sciences and the drive for a more unified conceptual framework in the social sciences. Although a thorough analysis of the evolution of social theory is beyond the scope of this book, the following section provides a brief summary of some of the major trends and developments that have bearing on the emergence of systems theory.[22]

In sociology, systems thinking is most commonly associated with the positivistic tradition represented in the work of Auguste Comte, Émile Durkheim, and the structural functionalism of Talcott Parsons. It is generally portrayed as antagonistic to the interpretive, or hermeneutic, tradition associated with Max Weber, symbolic interactionism, and critical theory. Of course, categorization of sociological theories is problematic. Parsons himself places his work in the Weberian tradition. In addition to positivist and interpretive approaches, a third category is often identified as the "conflict school," in the Marxist tradition, although Marx himself is often described as a positivist. At the same time, he shares roots in the German idealist tradition with Weber.[23]

An important consideration in sociological theory has to do with the relative roles of the individual and the collective in shaping social reality. Holistic and organismic models of society arose, in part, in reaction to the atomistic mechanism of individualistic theories of society, such as utilitarianism and social Darwinism, that tended to portray social order as resulting solely from the individual pursuit of self-interest, leaving open the question of the relative degrees of conflict or coherence between individual aspirations. Echoing similar arguments against the Gaia hypothesis, critics of holistic approaches in social theory generally object to what they see as the teleological nature of such models, in ascribing purposeful behavior to the society as a whole in maintaining itself and adapting its component parts to its larger needs. And they object to what they see as the implicit social determinism in these models, which neglects the role of active and conscious individuals.[24]

Pitirim Sorokin distinguishes between singularistic-atomistic theories and systemic theories, although he describes three different kinds of systemic theory: systemic theories of cultural systems, systematic theories of social systems, and integral systems of structural and dynamic sociology. In general, however, systemic models are seen, in the tradition of positivistic functionalism, as emphasizing objective over subjective considerations, reinforcing a kind of structural determinism, and downplaying the importance of individual agency. They are seen as *nomothetic,* or rule-based, in contrast to the *idiographic* orientation of the interpretive approaches that emphasize the importance of values and the meanings that individuals ascribe to their actions, as well as the unique and historical nature of social reality. In terms of Sorokin's distinctions between systems approaches, the system concept is most often associated with social structure, although the general-systems group was equally concerned with symbolic systems, and with the relationship between conservative and evolutionary elements of social systems.[25]

Positivism in sociology, defined basically as the application of the natural sciences to the study of society, emerged in parallel with organismic models of functional analysis. It is characterized by an objective analysis, in contrast to the emphasis on subjectivity in the German idealist tradition. In his discussion of positivism and sociology, Peter Halfpenny gives twelve different definitions of positivism, many of which are contradictory. He identifies two nineteenth-century roots of positivist thought, (1) in the work of Comte and the development of statistics and (2) in the later formulation of logical positivism in the early twentieth century. The earlier forms of positivism, represented in the works of Comte and Durkheim, were more influenced by biology, thus their functional and holistic character. Logical positivism, however, drew its primary influence from physics and was correspondingly more reductionist. While earlier forms of positivism sought fundamental laws of history, drawing on conceptions of development and evolution from biology, the latter forms were opposed to metaphysical (or theoretical) speculation of any sort and limited themselves to empirical investigation. Parsonian functional analysis, in its teleological view of society, was probably closer in spirit to the earlier forms of positivism than it was to logical positivism. In all its formulations, however, positivism appeals to the authority of science as the basis for a rational understanding of the social order.[26]

While Stuart Hughes characterizes the social thought of the period from 1890 to 1930 as a "revolt against positivism," mid-twentieth-century social thought might be seen as an attempt to integrate the insights of the earlier positivists with those of the "anti-positivists" of the progressive era. According to Halfpenny, logical positivism had roots in pragmatism, although it was probably closer in spirit to behaviorism in its emphasis on objectivity and quantification. An emphasis on methodology, practical techniques for collecting and manipulating data, and the identification of causal relationships between variables characterized the more modern forms of positivism, along with the overriding aim of creating a unified science that would tie together laws operating in different empirical domains, reflected in the primary objective of the Society for General Systems Research. Positivism might also be seen as a modern version of the Enlightenment belief in progress and the central role of science in the improvement of society.[27]

Halfpenny points out that positivism was initially motivated in defense of the freedom of human reason against the constraints of religion and traditional authority. However, he suggests that it "imposed its own unfreedom" in insisting that reason submit to experience, meaning that it is essentially constrained by present conditions. This conservative element in the positivist tradition, this "alignment of knowledge with the status quo," is at the heart of most critiques of positivism, as well as of many critiques of systems theories. As many critics have argued, the idea of self-regulating systems seeking to maintain themselves in equilibrium assumes a coherence in the goals and aims of their constituent components that does not exist in human society. As a result, as Anthony Giddens suggests, positivism is seen to represent the “philosophic expression of technocratic domination.” In excluding normative considerations from science, “technique” becomes a value in itself, and values tend to be expressed in terms of a technical rationality, as for example in game theory, the national accounting system and the GNP, or perhaps the Dow Jones Industrial Average.[28]

In defense of the systems view, I would suggest that the coherence of individual goals is not, in fact, a necessary assumption in representing the social order as a self-regulating system, especially if such a system is defined in interactive and evolutionary rather than equilibrium terms. The social order evolves through the interactions of its members. Systems theory focuses attention on the nature of that interaction, and the ways in which it is conditioned by the cultural context and the institutional structures of our lives. For Boulding, it highlighted the importance of dialogue and skills in negotiation and conflict resolution. The quest for peace is a quest for unity, and yet our world seems beset with an ideological commitment to conflict, on both ends of the political spectrum. Boulding spoke often of the need for mutual respect. It seems that our current situation calls us to reexamine our perception of the world in such polarizing terms.

THE ORIGINS OF MODERN SOCIAL THOUGHT

Sociology has often been described as a child of the industrial revolution. As Ronald Fletcher suggests, “the making of sociology was part of the task of making a new society.” Beginning with Saint-Simon, nineteenth-century social thought was concerned with the process of planned social change, seeking to understand and control the further evolution of industrial society. In some ways, it can be seen as a further development of Adam Smith’s economic model that had failed to consider the social ramifications of the capitalistic division of labor beyond the domain of the market. In his insightful analysis, Lewis Mumford wrote that the emergence of industrial society required a fundamental reorientation of values, habits, and ideas. The whole mode of life would have to be adapted to the “pace and capacities of the machine.” Anticipating the interdisciplinary climate of the postwar era, he suggested: “To understand the machine is to understand ourselves,” as the organic becomes visible “even within the mechanical complex.”[29]

A second important factor in the emergence of modern social thought was Darwin’s theory of natural selection, most notably in Spencer’s social Darwinism, although evolutionary concepts also informed the more holistic functionalist models. In spite of his individualistic emphasis on “the survival of the fittest,” Spencer’s model incorporated an appreciation of the functional interdependence of individuals within society. Drawing parallels between the functional needs of society and those of the organism, he argued that differentiation of structure and function increased with size. Further, as societies got larger and more complex, they required systems of regulation to control the action of the parts and insure their coordination. At the same time, Spencer was opposed to government intervention, which he thought would interfere with the process of natural selection and the adaptation of society to its environment. He attempts to reconcile these contradictory concerns by distinguishing between militant and industrial societies. While peaceful societies have weaker and more diffuse systems of internal regulations, militant societies tend to have more coercive and centralized controls.[30]

Jean Piaget wrote that the concept of structure includes the ideas of wholeness, transformation, and self-regulation, although functional approaches often tend to focus on structural relations and downplay transformational aspects. A. R. Radcliffe-Brown distinguishes functional approaches from evolutionary/historical approaches. However, even Comte and Durkheim, whose work provides the starting point for later functionalist approaches, were concerned with the processes of development and change in society. The relationship between the static element of structure and the dynamic aspects of social evolution and agency becomes critical in the development of social thought, as well as in the elaboration of general-systems concepts. Boulding often distinguished the evolutionary focus of his own approach with the more physiological, functionalist approach of Miller's living-systems theory.[31]

In one of the first functional analyses of society, Comte tried to include a consideration of both order and change, the static and dynamic aspects of the social order. However, he saw social evolution as proceeding along a predetermined course through theological, metaphysical, and scientific stages. In the scientific or positive stage, society would be governed by industrial administrators and scientific moral guides, reflecting the nineteenth century's optimistic faith in the progressive and self-correcting nature of science. His hierarchy of the sciences, proceeding from the most simple to the most complex, anticipates the organismic conception of emergent levels in biology, as well as the concern with hierarchical levels of organization in the general-systems community. And the holistic, organic model common to these approaches contains an implicit assumption of harmony between the whole and the parts of the social system, although Comte did acknowledge a need to suppress the potentially subversive impact of individualistic motivations.[32]

Unlike Spencer, who thought that social order derived from the competitive interactions between self-interested individuals, Comte believed that utililtarian considerations could not account for the complex interdependencies of human society. While Comte sought unifying laws that would integrate all of the sciences into a single natural system, he was opposed to the reductionism implicit in atomistic and individualistic models of society. Instead, he saw individuals as constituted by society, which was held together by ties of religion and language, and he sought empirical sociological laws that could help promote the establishment of social harmony, giving science the same control over individuals that it enjoyed in nature. Spencer, on the other hand, saw society primarily as a vehicle for the unfolding of individual purpose, although he, too, noted the role of language in binding society together and providing a kind of permanence in the relationships between individuals.[33]

Like Comte, Durkheim was opposed to reductionist explanations of social order that focused on biological or psychological interpretations. Rather, he was interested in the social-structural determinants of social reality. Echoing arguments of organismic biologists pertaining to the relative autonomy of different levels of organization, he suggested that social phenomena, though not superior to their component parts, had to be explained on their own level. He believed that society required some kind of integrative force to keep from disintegrating into a mass of "mutually antagonistic and self-seeking" individuals. For Durkheim, as for Comte, religion provided the normative constraint that bound the individual to the larger social order. However, he went beyond the primarily speculative orientation of Comte's work to lay the foundation for an empirical approach to the study of social phenomena, which was further developed in the functional analysis of anthropologists Radcliffe-Brown and B. Malinowski, and later in the sociological functionalism of Parsons and Robert Merton.[34]

All of the early social theorists placed considerable importance on the division of labor as a primary factor in the evolution of society, reflecting the industrial roots of modern social thought. Marx's emphasis on structure in his analysis of social classes places him in the positivist tradition. However, his insistence on the conflict inherent in the structural relations of social classes separated him from Comte and Durkheim, who emphasized functional coherence, minimizing such conflict in the interests of maintaining social order, and from Spencer, who saw conflict in more individualistic terms. Further, his emphasis on conflict as the core of the historical process was rooted in a critical perspective toward the existing status quo, while Spencer's model was easily used in its defense. In alignment with the idealist tradition, however, Marx was far more concerned with the historical specificity of a particular social context. And his emphasis on history was related to his belief in the materially and existentially determined nature of ideas and belief systems that earlier theorists had identified as primary determining factors. Also rooted in idealism was his belief in the possibility of a future society in which the underlying conflict would ultimately be resolved in an egalitarian communal society.[35]

THE INTERPRETIVE TRADITION

The interpretive tradition, as exemplified most notably in Weber's work, likewise has roots in German idealism, which Coser suggests was fundamentally opposed to organismic views of society. While the latter assumed a continuity between nature and society, the idealist tradition emphasized the qualitative differences between them. Human culture was seen to be a realm of freedom and autonomy that could best be understood through idiographic rather than nomothetic methods (i.e., focusing on historical uniqueness rather than general laws). This tradition drew its inspiration from the German historian Wilhelm Dilthey, who argued that understanding human history required an effort to gain a subjective perspective of the actual lived experience. Significantly, organicism in biology was more closely affiliated with idealism, and similarly emphasized the qualitative distinction between the organic and the inorganic realms. Just as it is history that makes society unique, so it is development and evolution that are the distinguishing characteristics of life.[36]

Such distinctions, however, nurtured an organismic holism in biology while they tended toward more antiholistic orientations in social thought. Rejecting social structure as the primary basis of social analysis, Weber was primarily concerned with the subjective meaning that humans ascribe to their actions. Interpretive sociology, for him, focused on the actions of the individual as its basic unit. Unlike behaviorism, however, with its objective analysis of human behavior, Weber sought an understanding of subjective motivations, including goals, values, emotions, and traditions. In the spirit of Hegel, he sought to highlight the "self-reflection of the knowing subject."[37]

Weber thought that Marx placed undue emphasis on economic relations of production as the single causative factor in human affairs. In contrast, he described the relationships between systems of thought and systems of social organization as multidimensional, with causal connections in both directions. He saw society as a balance of many different kinds of opposing forces, although ultimately he seems to succumb to a kind of structural determinism in his pessimistic belief in the inevitability of increasing bureaucratization and depersonalization, stifling the individual's personal desires in the inertia and power of the social collective. In contrast to Comte, Durkheim, and even Marx, he did not see a positive role for science in the regulation of society or as the basis for value judgements. Critics of functionalism echo his arguments in their desire for a theory of the subject, for an appreciation of practical consciousness, and for a treatment of human beings as capable knowledgeable agents.[38]

James Kloppenberg discusses significant parallels between the European interpretive tradition of Dilthey and Weber, and American pragmatism, particularly in the work of William James and John Dewey. He describes these two traditions as a via media between idealism and empiricism and between socialism/collectivism and liberalism/individualism. They might also be seen as mediating between holism and reductionism. He further discusses these parallels in terms of what he calls a "convergence in ideas about how we know and what we are to do." Beginning with a radical (or relativistic) theory of knowledge, with no Archimedean reference point, these social theorists anticipated later cybernetic perspectives on consciousness and learning, in their emphasis on the experiential nature of knowledge based on trial-and-error feedback loops. They saw ethics as historical and contingent, synthesizing Kantian and utilitarian ethics in their appreciation of the complementarity of rules and results in moral reasoning. Building on this epistemological and ethical synthesis, Kloppenberg suggests that they paved the way for a political synthesis in the emerging welfare state.[39]

While systems thinking is generally associated with the functionalist school of thought, the general-systems group drew from both interpretive and pragmatist traditions. Dewey, in particular, has been credited with a number of contributions to the systems view, including his concept of the reflex arc mediating perception and action, his insistence on the importance of understanding organisms in relation to their environment, and his concern with the relationship between the knower and his/her environment. Boulding acknowledged Weber as one of the most important intellectual influences in his thought. And William James's influence was passed on through his student E. A. Singer, whose work on inquiring systems was further developed and incorporated into the main body of systems literature by his own student, C. West Churchman.[40]

Park and Burgess, mentioned earlier in the chapter in connection with their perspectives on social ecology, drew most significantly from the work of Georg Simmel, who like Weber tried to integrate functionalist and idealist approaches in his view of society as a web of patterned interactions. Park sought to understand social relations in terms of the psychology of interacting individuals, echoing Weber in identifying volitional attitudes as the basic unit of social psychology, while at the same time arguing for the social determination of the individual's self-conception. The contributions of early American sociologists Lester Ward, William Graham Sumner, and Franklin Giddings should be taken into account as well, in shaping the distinctive focus in American social thought. While they differed in their political views, Ward favoring collectivization in contrast to Sumner's preference for laissez-faire, these sociologists made unique contributions in their concern with the psychological aspects of society, the central role of values in society, the organization of institutions, and the relationship between social influence and the formation of the individual personality.[41]

The role of society in shaping individual motivations and behavior was the central focus of the emerging discipline of social psychology, a discipline at the core of the new behavioral sciences. James Schellenberg describes social psychology as a multiparadigm science, combining psychoanalysis, symbolic interactionism, gestalt psychology, and behaviorism, with their respective emphases on the "inner emotional forces of the individual," the subjective determination of behavior within a specific social context, "present cognitive organization as the basis of behavior," and "present behavior as product of past behavior." Of its practitioners, the most signficant for the general-systems group were Kurt Lewin, who drew heavily from gestalt psychology in the formulation of his field theory of behavior, and George H. Mead, a pragmatist and the primary inspiration for the symbolic interactionist approach. Also important was the emergence of cultural anthropology with its emphasis on cultural evolution over natural selection in human society.[42]

Symbolic interactionism was associated with the University of Chicago's Department of Sociology. It drew its inspiration from Mead and the pragmatic tradition of Dewey and James, and was similar in spirit to the work of Park and Burgess, explaining behavior in terms of the social group(s) to which the individual belongs. While it focuses on the motivation of individual behavior, it recognizes no self apart from society and understands individual experience from the standpoint of society, specifically in terms of the role of communication in the creation of meaning and the maintenance of the social order. Park's work on the social role of newspapers exemplifies this tradition. The concern with culturally generated systems of meaning and their relationship with subjective individual experience and motivations, as well as with evolving social structures, is reflected in Bertalanffy's primary aim of exploring relationships between the dynamics of systems at the physical, biological, psychological, social, and symbolic levels, which he understood in both analogous and emergent terms.[43]

Common to both the symbolic interactionists and the general-systems group is an emphasis on relationships and the dynamics of interaction. Understanding interaction at the social level requires an analysis of language and mental constructs, as well as of the actual processes of communication in social contexts. In his introduction to Mead's *Mind, Self, and Society,* Charles Morris suggests that these concerns ultimately grew out of Darwin's theory of evolution, through a dawning awareness that the mind itself was an evolutionary development, arising out of the interaction between human organisms and their environment, and that societies themselves must be understood as very complex biological entities. He further describes pragmatism as an empirical naturalism, attempting to overcome the dualisms of "mind and matter, experience and nature, philosophy and science, teleology and mechanism, theory and practice." And, finally, he suggests that pragmatism is characterized by a commitment to both experimental method and the democratic tradition, ultimately undermining distinctions between fact and value. This integrative impulse informs the general-systems tradition as well, which is nevertheless most commonly associated with the more functional approach of Talcott Parsons's social-systems theory.[44]

PARSONIAN FUNCTIONALISM

As mentioned previously, the "Chicago school" of sociology lost its dominance in the mid-1930s. By the 1940s Parsonian frameworks and the broader influence of Walter Cannon and Lawrence Henderson in the Harvard community marked the dominant currents in American sociological thought. Cannon and Henderson applied the concepts of feedback, equilibrium, and homeostasis from their biological research to the dynamics of social organization and had a profound impact on the evolution of social theory during this period. Henderson, a biochemist turned social theorist, taught a popular course on the social theory of Vilfredo Pareto, who had developed his own model of the social system based on J. Willard Gibbs's thermodynamic formulation of a generalized physico-chemical system. Pareto had also drawn inspiration from the work of economist Léon Walras, a pioneer in the mathematization of economic relationships. In addition to Parsons, other sociologists who took Henderson's course included Robert Merton, George Homans, and Kingsley Davis.[45]

Coser credits Pareto with "the first precise statement of the idea of a social system that can be analyzed in terms of the interrelations and mutual dependencies between constituent parts." He was particularly interested in the nonrational aspects of human behavior, and was most noted for his analysis of the role of elites in society, providing legitimation for threatened elites in his critique of Marxism. Ghiselin argues that the organismic approach to society inherent in Pareto's systemic model assumes a level of teleology in the organization of society that lends itself to ideologies of social control and regulation. Hughes echoes this judgment in his characterization of Pareto as the "great rationalizer of authoritarian conservatism," although Coser suggests that Pareto's influence was fairly short-lived. While Parsons's early work was heavily indebted to Pareto, his later work drew more from Freud and the functional analysis of Malinowski and Radcliffe-Brown. Nevertheless, Pareto's influence remained, resurfacing after the publication of C. W. Mills's *Power Elite* (1959). Harold Lasswell, a political scientist who was very influential in the development of the Ford Foundation's behavioral-science program, drew heavily throughout his career on Pareto's work on the circulation of elites.[46]

In addition to Cannon, Henderson, and Pareto, the primary influences in the development of Parsons's thought were Durkheim and Weber. In his work he tried to synthesize insights from the positivist, utilitarian, and idealist traditions. Coser, in fact, describes Parsons as opposed to positivism in his attempt to develop a "voluntaristic theory of social action," although structural elements tended to dominate in his work. Parsons rejected the atomistic focus of the utilitarian tradition, although he agreed with its view of individuals as purposive and goal-oriented. While he acknowledged the German idealist tradition for its treatment of the influence of ideas, he felt that it did not give sufficient consideration to social structures. Parsons sought to account for the dynamic interaction between ideas and social structures, incorporating a consideration of actors, goals, choices, constraints, norms, and values.[47]

Like earlier theorists, Parsons drew parallels between organic and social/cultural evolution, building on the "fundamental continuity of society and culture as part of a more general theory of the evolution of living systems." Rather than focusing on competition between individuals, however, he was interested in the adaptive capacities of societies, suggesting that modern industrial societies were more generally adaptable than other types. Parsons's framework for the analysis of social action was based on the identification of four primary functions in society—adaptation, goal-attainment, integration, and pattern maintenance—associated respectively with the domains of behavior, personality, society, and culture.[48]

Parsonian functional analysis tended to focus on the consequences of specific social actions for the structures in which they were embedded. Building on ideas of homeostasis and feedback from Cannon, it analyzed the ways in which such consequences were "fed back" to the original actors, reinforcing or modifying further action. This approach tended to reinforce a top-down model of causality. In the Parsonian system, cultural systems of meaning controlled social systems, just as social systems controlled the personality systems of individual actors, which in turn directed their behavior. This cybernetic hierarchy of control gave priority to cultural and symbolic factors, portraying social institutions as essentially communication systems. Parsons's book *The Social System,* published in 1951, was primarily concerned with stable patterns of interaction rather than individual agency, emphasizing institutionalized values, norms, and social roles.[49]

Echoing George Richardson's distinction between the two strands of feedback thought, Alvin Gouldner describes Parsons's work, in the tradition of Comte and Durkheim, as focusing on external sources of change in the system, in contrast with Marx, who highlighted internal contradictions as the primary source of disequilibrium and change. Parsons tended to ignore internal sources of conflict. Richardson points out that for most social scientists, the concept of feedback was automatically associated with homeostasis, leaving out the important role of positive feedback in the dynamics of change.[50]

According to Gouldner, some of the difficulties with systems models stem from decisions about what to include in the system, as well as what kind of model to use. He notes, for example, that Parsons did not sufficiently address biological, ecological, or psychological dimensions in his social-systems models. He suggests, further, that most systems models are based on assumptions of interdependence between the parts of the system and an inherent tendency for these parts to maintain equilibrium in their relationships, although he points out that equilibrium does not always result from interdependence. For Parsons, any social process that did not contribute to the maintainance or development of the system was dysfunctional, in detracting from the integration and effectiveness of the system. His model failed to provide a critical perspective from which to evaluate the system itself.[51]

Parsons chaired the Department of Social Relations at Harvard, which incorporated the fields of social and clinical psychology, social anthropology, and sociology, for ten years during the 1950s, and his functional approach, along with that of Merton at Columbia, dominated American sociology into the 1960s. The conservative bias that was inherent in his concern with the maintenance of the system as a whole, however, eventually led to its decline. Although he attempted to address the problems of conflict and social change in his later work, the 1970s witnessed a shift away from macrosociological and structural concerns to more pluralistic and idiographic orientations. While both traditions concern themselves with relationships between systems of meaning, social structures, and individual actions, the functionalist tradition emphasized structural elements while more recent approaches tend to reject the conceptual generalizations of the functional approach, emphasizing instead the conflictual dynamics of interacting individuals.[52]

Parsons's work, however, had a profound impact on the further evolution of social theory, as a primary foil for alternative perspectives, most notably in the work of Jürgen Habermas, a critical theorist in the tradition of the Frankfurt school. Habermas has been a prominent critic of Niklas Luhmann, one of the foremost proponents of social-systems theory in Germany, whose early work was rooted in the Parsonian framework. On the basis of this vision of "systems theory," Habermas describes the instrumental rationality of the "system world" as controlling and subordinating the "life world" of the individual. The perception of systems views as eclipsing subjective perception and individual difference may be accurate in relation to Parsons and other "social systems theories" derived from his work. But, it does not accurately reflect the implications of *general* system theory as conceived by its founder, Ludwig von Bertalanffy, nor does it apply to other developments in the general-systems tradition, some of which have drawn significant inspiration from Habermas. These themes will continue to inform my discussion of the background and contributions of the founders of the Society for General Systems Research, and of further developments in the ongoing evolution of the society.[53]

NOTES

1. Pitirim Sorokin, *Sociological Theories of Today* (New York: Arno Press, 1979), p. 64.

2. See "Report from Iron Mountain," in Kenneth Boulding, ed., *Peace and the War Industry* (Chicago: Aldine, 1970), p. 77. Len Duhl, a longtime systems thinker and social-change artist, was one of several commentators on the *Report from Iron Mountain,* a satirical hoax purporting to be a secret, government-funded study on the necessity of war for maintaining the American economy (see Chapter 8 for further discussion).

3. See Donald Worster, *Nature's Economy* (San Francisco: Sierra Club Books, 1978), for a thoughtful analysis of the use of economic metaphor in the evolution of ecological thought.

4. Sharon Kingsland, "Defining Ecology as a Science," in L. A. Real and J. H. Brown, eds., *Foundations of Ecology: Classic Papers with Commentaries* (Chicago: University of Chicago Press, 1991), p. 3; Ernst Haeckel, *Generelle Morphologie der Organismen allgemeine Grundzüge der organischen Formen-Wissenschaft* (Berlin: G. Reimer, 1866).

5. Peter Taylor, "Technocratic Optimism, H. T. Odum, and the Partial Transformation of Ecological Metaphor After World War II," *Journal of the History of Biology* 21:2 (summer 1988): 235, 238–239. See further discussion of Taylor's critique of Odum in Debora Hammond, "Ecology and Ideology in the General Systems Community," *Environment and History* 3 (1997).

6. Sharon Kingsland, *Modeling Nature: Episodes in the History of Population Biology* (Chicago: University of Chicago Press, 1985). See also Eugene Cittadino, "The Failed Promise of Human Ecology," in Michael Shortland, ed., *Science and Nature: Essays in the History of the Environmental Sciences* (Oxford: Alden Press, 1993).

7. Gregg Mitman, *The State of Nature: Ecology, Community, and American Social Thought, 1900–1950* (Chicago: University of Chicago Press, 1992), p. 1; Anna Bramwell, *Ecology in the Twentieth Century: A History* (New Haven: Yale University Press, 1989), p. 40; Daniel Botkin, *Discordant Harmonies* (New York: Oxford University Press, 1990); and Donald Worster, "The Ecology of Order and Chaos," *Environmental History Review* 14:1–2 (spring/summer 1990): 1–18.

8. Donald Worster, "Grass to Dust: Ecology and the Great Plains in the 1930s," *Environmental Review* 3 (1977): 2–11, and *Nature's Economy,* pp. 291–311, 320. See Frederic Clements, *Plant Succession* (Washington, DC: Carnegie Institution, 1916) and "Nature and Structure of the Climax," *The Journal of Ecology* 24 (1936): 252–284. Clements published the first American textbook in ecology, *Research Methods in Ecology* (New York: Arno Press, 1977/1905). Michael Ghiselin notes that Clements's work was promoted in South Africa by the holistic philosopher J. C. Smuts (*The Economy of Nature and the Evolution of Sex* [Berkeley: University of California Press, 1974], p. 31).

9. Mitman, *The State of Nature,* p. 87. The Chicago group included Allee, Charles Child, Charles Herrick, Alfred Emerson, Thomas Park, Orlando Park, and Karl Schmidt, and their work is best exemplified in the coauthored text *Principles of Animal Ecology* (Philadelphia: W. B. Saunders, 1949). See Sharon Kingsland's discussion of the antireductionism in the animal behavior studies of Child and Herrick in Keith Benson, Jane Maienschein, and Ronald Rainger, eds., *The Expansion of American Biology* (New Brunswick: Rutgers University Press, 1991), pp. 195–223.

10. Ralph Gerard, "Notes for Dartmouth Convocation," 1960, in Ralph Waldo Gerard Collection, Department of Special Collections, University of California at Irvine (hereafter RWG), Box 25, pp. 1–2; Ghiselin, *The Economy of Nature,* pp. 31, 224–225 (quote p. 247). See Mitman, *State of Nature,* p. 5, for a discussion of Wheeler's influence on the group of

ecologists at Chicago. Of course, there are still biologists and ecologists who emphasize cooperation and symbiosis. Jan Sapp, for example, has argued for the importance of symbiosis in the evolutionary process, in "Cell Evolution and Organelle Origins: Metascience to Science," *Archiv für Protisten Kunde* 145 (1995): 263–275, and "Symbiosis and Disciplinary Demarcations: The Boundaries of the Organism," *Symbiosis* 17 (1994): 91–115. He suggests ("Symbiosis," p. 91) that the emphasis on conflict and competition in nature reflects dominant views of human social progress, which is inherently opposed to studies of symbiosis. See Taylor, "Technocratic Optimism," pp. 234–235, on the sociopolitical implications of organicism in ecology.

11. T.F.H. Allen and Thomas W. Hoekstra, *Toward a Unified Ecology* (New York: Columbia University Press, 1992), p. 45; Worster, *Nature's Economy,* pp. 291–311; Joel Hagen, *An Entangled Bank: The Origins of Ecosystem Ecology* (New Brunswick: Rutgers University Press, 1992), p. 136; Herbert Gleason, "The Individualistic Concept of the Plant Association," *Bulletin of the Torrey Botanical Club* 53 (1926): 7–26; Arthur Tansley, "The Use and Abuse of Vegetational Concepts and Terms," *Ecology* 16 (1935): 284–306; and personal interview with Arnold Schultz, professor of ecosystemology at the University of California at Berkeley, spring 1996.

12. Taylor, "Technocratic Optimism," pp. 213–244 (particularly his discussion of Hutchinson's participation in the Macy conferences on cybernetics), and "Ecosystems as Circuits: Diagrams and the Limits of Physical Analogies," *Biology and Philosophy* 6:2 (April 1991): 275–294. See, for example, G. E. Hutchinson, "Circular Causal Systems in Ecology," *Annals of the New York Academy of Science* 50 (1948): 221–246; and Raymond Lindeman, "The Trophic-Dynamic Aspect of Ecology," *Ecology* 23 (1942): 399–418.

13. Frank Golley, *A History of the Ecosystem Concept in Ecology* (New Haven: Yale University Press, 1993), pp. 2–4.

14. Ibid., pp. 177–180; Kingsland, *Modeling Nature,* pp. 3–5. See also Worster, *Nature's Economy;* Hagen, *An Entangled Bank;* and Chunglin Kwa, "Radiation Ecology, Systems Ecology, and the Management of the Environment," in Michael Shortland, ed., *Science and Nature: Essays in the History of the Environmental Sciences* (Oxford: Alden Press, 1993).

15. Kingsland, *Modeling Nature,* pp. 1–5, 8. See Alfred Lotka, *Elements of Physical Biology* (Baltimore: Williams and Wilkins Company, 1925); and Vito Volterra, *Leçons sur la théorie mathématique de la lutte pour la vie* (Paris: Villars, 1931).

16. Allen and Hoekstra, *Toward a Unified Ecology,* pp. xiii–vi, 12–14, 33.

17. Kenneth Boulding, Review of Howard Odum's *Energy Basis for Man and Nature* (New York: McGraw-Hill, 1976), in *Friend's Journal* 23:9 (1977): 276–277; Taylor, "Technocratic Optimism," p. 227. Taylor is referring to Robert Lilienfeld, *The Rise of Systems Theory: An Ideological Analysis* (New York: Wiley, 1978).

18. Golley, *A History of the Ecosystem Concept,* p. 168; Hagen, *An Entangled Bank,* pp. 1, 6; Kingsland, *Modeling Nature,* p. 6. See also Cittadino, "The Failed Promise," pp. 272–274, 282, regarding the hope among ecologists for a science-based social order.

19. Cittadino, "The Failed Promise," p. 283. See also Geoffrey Vickers's foreword to F. E. Emery and E. L. Trist, *Towards a Social Ecology: Contextual Appreciation of the Future in the Present* (New York: Plenum Press, 1972), p. vi.

20. Robert Park, *On Social Control and Collective Behavior* (Chicago: University of Chicago Press, 1967), p. xxvi, and *Human Communities: The City and Human Ecology; The Collected Papers of Robert Ezra Park,* vol. 2 (Glencoe, IL: The Free Press, 1952), pp. 146–147. Taylor points out that Eugene and Howard Odum's father, Howard Washington Odum, had been a promoter of the cooperative, organicist vision of Ward's dynamic sociology ("Technocratic Optimism," p. 223).

21. Park, *On Social Control,* pp. xxi–xxii, and *Human Communities,* pp. 154–157. See also Winifred Raushenbush, *Robert E. Park: Biography of a Sociologist* (Durham, NC: Duke University Press, 1979), pp. 164–166; and Fred Matthews, *Quest for an American Sociology: Robert E. Park and the Chicago School* (Montreal: McGill-Queen's University Press, 1977), pp. 145–146. Alvin Goulder writes, "No tradition of sociological analysis better understood the systemic character of these historically new structures [news media and communication] than the 'Chicago School' " (Goulder mentions Cooley and Bogardus in addition to Park and Burgess), although they still tended to downplay historicity and class, in a kind of decontextualizing notion of information, in *The Dialectic of Ideology and Technology: The Origins, Grammar, and Future of Ideology* (New York: Seabury Press, 1976), pp. 118, 136.

22. Lewis Coser, *Masters of Sociological Thought: Ideas in Historical and Social Context* (San Francisco: Harcourt Brace Jovanovich, 1977/1971), pp. 561–562. Coser writes that Parsons's *The Structure of Social Action* (New York: McGraw-Hill, 1937) marked an important watershed in the evolution of American sociology, along with the 1935 establishment of *The American Sociological Review* independent of the previously dominant Chicago department. Albion Small was also an important member of the Chicago group. See also David Easton, ed., *Varieties of Political Theory* (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1966), pp. iii–iv, 2–6, on the role of theory in the evolution of the behavioral sciences.

23. Coser, *Masters of Sociological Thought,* pp. 561–582; Talcott Parsons, *The System of Modern Societies* (Englewood Cliffs, NJ: Prentice-Hall Inc., 1971), pp. 1–2; Sorokin, *Sociological Theories,* pp. 9–10; Anthony Giddens, *Profiles and Critiques in Social Theory* (London: MacMillan Press, 1982), pp. 1–2, 85. Sorokin discusses a number of different schemas for classifying sociological thought. In particular he mentions H. R. Wagner, in "Types of Sociological Theory: Toward a System of Classification," *American Sociological Review* (October 1963): 735–742, who divides sociological theory into three types: positive, interpretive, and nonscientific or evaluative. In his discussion of recent trends in American sociological theory, Coser uses the term "conflict school" with some qualifications. In this tradition he mentions C. W. Mills, whose work was influenced by both Marx and Weber. Raymond Aron traces a continuity in the work of Parsons, Weber, and Marx, in *Main Currents in Sociological Thought* (Garden City, NY: Doubleday and Company, 1970/1967), p. vi.

24. Giddens, *Profiles and Critiques,* pp. 8–10; Ghiselin, *The Economy of Nature,* p. 220; D. C. Phillips, *Holistic Thought in Social Science* (Stanford, CA: Stanford University Press, 1976), pp. 42–43, 93.

25. Sorokin, *Sociological Theories,* p. 10; Giddens, *Profiles and Critiques,* pp. 19, 34; Dorothy Ross, *The Origins of American Social Science* (Cambridge: Cambridge University Press, 1991), p. 362.

26. Giddens, *Profiles and Critiques,* p. 2; Peter Halfpenny, *Positivism and Sociology: Explaining Social Life* (Boston: George Allen and Unwin, 1982), pp. 11–12, 46, 114–118; Ross, *Origins,* p. 327. Halfpenny attributes the teleological nature of functional models to their tendency to see functional laws as a kind of causal law, particularly with reference to negative feedback.

27. Stuart Hughes, *Consciousness and Society: The Reorientation of European Society Thought, 1890–1930* (New York: Alfred A. Knopf, 1961), pp. 33–66; Halfpenny, *Positivism and Sociology,* pp. 56–61; Ross, *Origins,* p. 311. Halfpenny refers, in particular, to Charles Pierce's argument that the meaning of a concept is given by its practical effects. In contrast to Hughes's characterization of the progressive era, Ross describes American social thought during this period in positivisitic terms, as increasingly quantitative and scientistic, and geared primarily toward social control.

28. Halfpenny, *Positivism and Sociology,* p. 119; Ross, *Origins,* p. 383; Giddens, *Profiles and Critiques,* p. 91.

29. Richard Peterson, *The Industrial Order and Social Policy* (Englewood Cliffs, NJ: Prentice Hall Inc., 1973), pp. 1–5, 14; Ronald Fletcher, *The Making of Sociology: A Study of Sociological Theory* (New York: Charles Scribner's Sons, 1971), p. 452; Lewis Mumford, *Technics and Civilization* (New York: Harcourt, Brace and Company, 1934), pp. 3–6.

30. Phillips, *Holistic Thought,* pp. 89–91; Coser, *Masters of Sociological Thought,* pp. 90–93, 99–100; Charles Morris, "Introduction," in George H. Mead, *Mind, Self, and Society,* C. W. Morris, ed. (Chicago: University of Chicago Press, 1967/1934), pp. ix–x; Ross, *Origins,* p. 361.

31. References to Piaget and Radcliffe-Brown are in Phillips, *Holistic Thought,* pp. 84, 105. See also Kenneth Boulding, "The Next Thirty Years in General Systems," *General Systems* 29 (1985): 3, and "Systems Profile: Some Origins," *Systems Research* 4:4 (1987): 287.

32. Coser, *Masters of Sociological Thought,* pp. 3–13; Halfpenny, *Positivism and Sociology,* pp. 13–15.

33. Coser, *Masters of Sociological Thought,* pp. 10–11, 90, 98; Halfpenny, *Positivism and Sociology,* pp. 14–15, 18; Phillips, *Holistic Thought,* pp. 38, 44, 81–81; Giddens, *Profiles and Critiques,* p. 72. Reino Virtanen suggests that Comte was influenced by the work of Claude Bernard, who indirectly shaped later functionalist thought through his intellectual descendants, Lawrence Henderson and Walter Cannon, in *Claude Bernard and His Place in the History of Ideas* (Lincoln: University of Nebraska Press, 1960).

34. Coser, *Masters of Sociological Thought,* pp. 129–142 (quote p. 132); Giddens, *Profiles and Critiques*, p. 61.

35. Coser, *Masters of Sociological Thought,* pp. 43–44, 48, 54.

36. Coser, *Masters of Sociological Thought,* pp. 177, 220; Giddens, *Profiles and Critiques,* p. 15.

37. Coser, *Masters of Sociological Thought,* pp. 217–218; Giddens, *Profiles and Critiques,* p. 84 (quote). Coser cites Weber in Hans Gerth and C. W. Mills, *From Max Weber: Essays in Sociology* (Oxford: Oxford University Press, 1946), p. 55.

38. Coser, *Masters of Sociological Thought,* pp. 222, 228, 231–233; Giddens, *Profiles and Critiques,* pp. 8–10.

39. James Kloppenberg, *Uncertain Victory: Social Democracy and Progressivism in European and American Thought, 1870–1920* (Oxford: Oxford University Press, 1986), pp. 3–9 (quote p. 3).

40. Phillips, *Holistic Thought,* p. 50. See Kenneth Boulding, *The Image: The Place of Knowledge in Organisms and Organizations* (Ann Arbor: University of Michigan Press, 1956). The comment regarding Singer's influence is based on extensive personal interviews with Churchman from April 1993 through 1995.

41. Fletcher, *Making of Sociology,* pp. 581, 589–590; Coser, *Masters of Sociological Thought,* pp. 177–178, 562; Ross, *Origins,* pp. 358, 436.

42. James Schellenberg, *Masters of Social Psychology: Freud, Mead, Lewin, and Skinner* (New York: Oxford University Press, 1978), pp. 4–6; Ghiselin, *The Economy of Nature,* p. 220.

43. Coser, *Masters of Sociological Thought,* p. 334.

44. Morris, "Introduction," pp. ix–xv (quote p. x).

45. Coser, *Masters of Sociological Thought,* pp. 387, 407, 423, 561–565; Ghiselin, *Economy of Nature,* pp. 30–31, 224.

46. Coser, *Masters of Sociological Thought,* pp. 388, 402 (quote), 425; Hughes, *Consciousness and Society,* p. 82; Aron, *Main Currents,* p. 6; C. Wright Mills, *The Power Elite* (Oxford: Oxford University Press, 1959).

47. Coser, *Masters of Sociological Thought,* p. 563.

48. Parsons, *The System of Modern Societies,* pp. 2–5 (quote p. 2); Coser, *Masters of Sociological Thought,* p. 570.

49. Coser, *Masters of Sociological Thought,* pp. 562–564, 571; Talcott Parsons, *The Social System* (New York: Free Press, 1951).

50. George Richardson, *Feedback Thought in Social Science and Systems Theory* (Philadelphia: University of Pennsylvania Press, 1991), p. 48.

51. Alvin Gouldner, *For Sociology: Renewal and Critique in Sociology Today* (New York: Basic Books, 1973), pp. 180–181, 190–192, 218.

52. Coser, *Masters of Sociological Thought,* pp. 568, 571–574; Parsons, *The System of Modern Societies,* p. 143.

53. Jürgen Habermas, *The Philosophical Discourse of Modernity* (Cambridge, MA: MIT Press, 1992), pp. 368–385. The Frankfurt school of critical theory grew out of the work of Max Horkheimer and Theodor Adorno. See Martin Jay, *The Dialectical Imagination: A History of the Frankfurt School and the Institute of Social Research, 1923–1950* (Boston: Little, Brown, 1973).

PART II
The Founders of General Systems Research

SIX
Ludwig von Bertalanffy (1901–1972): General Systems Theory

> The humanistic concern of general system theory as I understand it makes a difference to mechanistically oriented system theorists speaking solely in terms of mathematics, feedback and technology, and so giving rise to the fear that system theory is indeed the ultimate step towards mechanization and devaluation of man and towards technocratic society.
>
> —Ludwig von Bertalanffy, *General System Theory*[1]

Ludwig von Bertalanffy is probably one of the more misunderstood figures in the history of science. His conception of general system theory (GST)—note that Bertalanffy used *system* in the singular, while today it is commonly referred to in the plural—was rooted in his concern with the development of a broader and more holistic theoretical framework in biology, although his association with the technologically oriented development of systems ideas often contributes to the misinterpretation of his work, particularly in terms of its implications for understanding social systems. Bertalanffy himself contributes to the confusion, because he often identifies GST with the broad development of systems approaches, including cybernetics, information theory, game theory, systems analysis, etc. At the same time, he distinguishes the humanistic focus of his own approach from the more mechanistic and technocratic orientation of other contemporary systems approaches. Ironically, Ido Hoos cites a similar passage in her critique of systems analysis, arguing that Bertalanffy provided the theoretical basis for systems analysis, which he saw as "serving and hastening" such mechanization and devaluation, as if this were what he was hoping to promote. Not only does she fail to acknowledge the critical element in Bertalanffy's view, but the evolution of systems analysis also has quite different roots.[2]

Bertalanffy identifies most strongly with Heraclitus, Nicholas of Cusa, and Leibniz, in their emphasis on the dynamic and dialectical nature of knowledge and reality, and specifically in connection with Leibniz's effort to overcome dualistic thinking, integrating knowledge into a "universal mathematics." Bertalanffy was also profoundly influenced by Goethe's work on organic form. David Berlinski describes him as having a passion for synthesis and the union of opposites; his work cut across traditional disciplines, as well as cultural and ideological boundaries, and he sought to overcome the separation between fact and value characteristic of modern science. Aldous Huxley, with whom he maintained a close friendship, described him as "one of those strategically placed thinkers whose knowledge in many fields permits them to strike at the joints between the various academic disciplines and so to penetrate to the quick of the living reality in a way which the specialist can never do."[3]

Most importantly, Bertalanffy saw the systems view as an alternative to the reductionist methodology and mechanistic values of the industrial revolution: "The acceptance of living beings as machines, the domination of the modern world by technology, and the mechanization of mankind are but the extension and practical application of the mechanistic conception." As a student of Moritz Schlick, Bertalanffy frequently attended meetings of the Vienna circle, although he was never a formal member. While he was sympathetic with their ideal of unifying science, he was critical of the reductionism inherent in logical positivism. Robert Rosen, a biologist who was influenced by Bertalanffy's work, remarked, "Whereas I viewed the reductionisms and materialisms rampant in biology merely as scientifically inadequate, von Bertalanffy saw them as evil and dehumanizing; in the deepest sense immoral." In contrast, he saw the systems perspective, with its emphasis on relationship, as the basis of a new scientific paradigm that offered both science and humankind something better.[4]

Bertalanffy is generally acknowledged as the founder of GST, although, as is common in the history of science, his priority has been disputed. "General systems theory" is somewhat of a misnomer, since the term really refers to "a way of thinking about" or "an approach to studying" complex systems. Because the meaning of the term is so diffuse, it is difficult to say what priority would mean. Bertalanffy himself describes GST as "a field where this author made a modest contribution." He was certainly one of the first to articulate the general-systems approach as a comprehensive world view in contrast to that of classical mechanistic science. Anatol Rapoport describes him as the first biologist to attempt to outline theoretical biology as a natural science. He is also credited with being the first to advocate an "organismic" approach in biology; in a letter recommending Bertalanffy for a Guggenheim fellowship, Ralph Gerard wrote, "Bertalanffy is certainly one of the most steady, sound, and stimulating of the small band of thinkers and writers in this area [organismic thinking in the field of biology]. His efforts in this direction are therefore precious and should have every possible support."[5]

The concept of the organism as an open system, introduced in 1940, is Bertalanffy's most important contribution to the evolution of systems thinking, providing the basis for further work in nonequilibrium thermodynamics, most notably by Ilya Prigogine. Bertalanffy was interested in a broad range of issues, and widely read in numerous fields of study. While his early work focused on theoretical issues in biology, his interests expanded to include philosophy, psychology, and the social sciences. His most significant contributions in biology include work in cytology, cancer research, and the comparative physiology of metabolism; his model of animal growth is widely used even today in commercial fisheries.

Bertalanffy distinguishes between three general developments in the systems field: systems technology, systems science, and systems philosophy. In the narrowest sense, systems theory is primarily a mathematical field, linked with the emergence of computers, and arising out of technological and administrative concerns relating to the increasing complexity of modern technological systems. The primarily instrumental focus of this orientation makes the systems idea potentially, as he suggests, "the ultimate technique to shape man and society ever more into the 'megamachine' which Mumford has so impressively described." Systems science, however, transcends technological problems, reflecting a reorientation that has become necessary in all sciences, from physics and biology to the behavioral and social sciences, emphasizing relationships between parts. Even more comprehensively, Bertalanffy suggests that systems philosophy deals with a reorientation in world view in contrast with the mechanistic, analytic, and linear causal paradigm of classical science. For Bertalanffy, general systems theory was "a new philosophy of nature" that emphasized the organized nature of the world. In his biography of Bertalanffy, Mark Davidson describes GST as "a science and philosophy of synthesis," emphasizing its holistic, ecological, and integrative orientation in contrast to the mechanistic orientation of the narrower, technological approaches. Some of the confusion regarding Bertalanffy's work results from the inherent tension between its scientific and philosophical dimensions.[6]

Bertalanffy's conception of GST arose out of his earlier work in theoretical biology and his sense that biological organisms should be studied as wholes. In attempting to overcome the dichotomy between vitalism and mechanism, Bertalanffy suggested that the unique characteristic of living systems was their organization, and that the field of biology should concern itself with investigating principles of biological organization scientifically. In contrast to the reductionism that was prevalent in contemporary approaches to physiology and developmental mechanics, Bertalanffy emphasized the importance of studying interactive relationships. His most important contribution to the development of such an approach was the concept of the organism as an open system, maintaining itself in a nonequilibrium steady state through continual interaction with its environment. The impetus for GST came from his sense that this concept was also relevant in other fields and could be applied to the study of the human psyche, social institutions, and the global ecosphere, where similar laws of organization might apply. Bertalanffy envisioned GST as an interdisciplinary search for such laws. His efforts to articulate these laws mathematically, along with his emphasis on "isomorphies" (i.e., similarities in formal mathematical structure) between different kinds of systems, were the most controversial aspects of his approach.[7]

Even more importantly, however, Bertalanffy saw GST as broadening the scope of inquiry to include all relevant factors. Beyond finding the most effective means of achieving a specified end, it included an evaluation of the process for determining goals, grounding technical rationality in the larger social and cultural context. While there is a tendency to see the systems view as reinforcing a rigid status quo and suppressing conflict, for Bertalanffy it implied the necessity of examining social and ecological problems from a global perspective that included different ways of looking at things. For him there was no one privileged perspective, and he constantly emphasized the importance of acknowledging multiple points of view, reflecting his understanding of the epistemological and ethical implications of GST: "All our knowledge . . . only mirrors certain aspects of reality. . . . Ultimate reality is a unit of opposites; any statement holds from a certain viewpoint only, has only relative validity, and must be supplemented by antithetic statements from opposite points of view." Based on recent discoveries in physics, Bertalanffy posited his "perspective philosophy," arguing that perception was not a reflection of "real things," but instead the result of a complex interaction between the knower and the known that was dependent on biological, psychological, cultural, and linguistic factors. Rather than fostering a totalizing conception of reality, Bertalanffy believed that interdisciplinary research would prevent one-sidedness.[8]

While systems theory and cybernetics are generally equated, Bertalanffy made a sharp distinction between his conception of general systems, which emphasized the open-system nature of living systems, and the cybernetic view. From his perspective, the cybernetic view reinforced equilibrium models of natural and social systems, while the open-system concept was explicitly evolutionary, emphasizing the importance of spontaneity and creativity. Of course, Bertalanffy's own work was eclipsed by the popularity of cybernetics, at least in the United States, and it was important for him to highlight the distinctions, not all of which are entirely accurate. His work probably had the most direct impact in the fields of psychology and psychiatry. Bertalanffy was critical of the stimulus-response model in behaviorist psychology, which he thought was retained in the cybernetic model, because it represented the organism as entirely passive, contributing to a view of humanity that justified totalitarian forms of social control. On the contrary, he argued, "Scientific control of society is no highway to utopia." He emphasized the active and self-organizing character of human behavior, which he thought would reinforce a more dignified image of humankind. Roy Grinker describes his conception of the personality as an active system as the third revolution in psychology.[9]

This "new image of man," in contrast to the behavioristic conception of "man as a robot," was at the root of Bertalanffy's theory of values. He argued that human behavior could not be explained purely in terms of biology, that it is also influenced by the individual's understanding of self in relation to the world. Human beings are creatures of two worlds, biological organisms living in a universe of symbols. It was the symbolic dimension, and specifically the system of values, that was decisive in shaping behavior, in Bertalanffy's view. He believed that humanity's image of itself and its corresponding system of values would be dramatically different if the world was seen as an organized whole rather than a collection of "physical particles governed by chance events." Values would thus be rooted in an awareness of interconnectedness and interdependence. Furthermore, because of its emphasis on the nonequilibrium nature of living systems, Bertalanffy thought his approach acknowledged the significance of uniqueness and individuality while other system conceptions did not.[10]

Although William Gray and Nicholas Rizzo refer to Bertalanffy as "one of the most profound and creative thinkers of the 20th century," he nevertheless had a mixed reception among his peers. In a letter to Clark Kerr, Kenneth Boulding wrote, "He is, I understand, a somewhat controversial figure among the biologists. He also suffers from mannerisms which do not always contribute to a good first impression. I am, however, much impressed with his writings." On a more humorous note, Boulding wrote to Ralph Tyler, in a letter recommending Bertalanffy as a fellow at the Center for Advanced Studies in the Behavioral Sciences (CASBS), "I think some biologists regard Bertalanffy as a bit of a crank, but he strikes me as being a very stimulating and productive crank, and being a bit of a crack pot myself, I have a strong fellow feeling." In a memo to Boulding, James Miller wrote, "If Bertalanffy had not been such a complex person, we naturally would have thought seriously about having him with us. Certainly I respect many of his ideas as central to our thinking." In his introduction to Davidson's biography of Bertalanffy, Boulding describes him as kindly and shy, with a "mixture of confidence that he was saying something important and diffidence that grew out of the lack of people to receive it." Rosen wrote of Bertalanffy that he "radiated a simple goodness, a largeness of mind, and a dignity notably absent in those that attacked him so violently, such as the molecular biologist Jacques Monod, [who] was typical of the excessively positivist, algorithmic, brute-force people who naturally cluster around the idea that reductionism (or as Monod preferred, analysis) is all there is to science."[11]

Bertalanffy himself often commented that new ideas are usually attacked and refused, and then later declared to be old and self-evident. He saw himself as attempting to combat deeply rooted habits of thought. He was a harsh critic of society in general and of the academic community in particular, and in a sense he was somewhat of an outsider in both. Citing Alexis de Tocqueville, he concurred that Americans were "devoted to practical science" and "averse to general ideas and theoretical discoveries." Reflecting his own difficulties in securing a position, he wrote that "American universities . . . are not the place for the breeding and care of such abnormalities as outstanding scientists." Further, he argues that there is no genuine welcome for "creative individuals who, by definition, are nonconformists, . . . [and] are sometimes awkward in public relations." On an even more revealing note, he continues: "You just cannot play opera without prima donnas, even if they sometimes have difficult personalities and do not care about 'togetherness.' . . . Science depends on men with leadership qualities, initiative, drive, character, and moral courage. It is these qualities which the present system hampers and paralyzes."

Nevertheless, his students generally spoke very highly of him. One wrote, "Only this spring did I discover what science was and what it implied. . . . This I attribute to the teaching of one of the finest men I shall ever meet."[12]

VIENNA: GREETING A NEW CENTURY

Ludwig von Bertalanffy was born on September 19, 1901, in Atzgersdorf, Austria, near Vienna. The von Bertalanffys belonged to the Hungarian nobility, and Ludwig's family was fairly wealthy until they lost most of their fortune in the economic collapse following World War I. His father, Gustav, was a railway administrator and his mother, Charlotte Vogel, was the daughter of a publisher. Ludwig was the only surviving child and his parents were divorced as he began school. Although he graduated from the gymnasium with honors, he did not attend classes, but studied at home on his own, which may account for his unconventional approach. In his youth he was influenced by Paul Kammerer, a neighbor who was somewhat notorious for his advocacy of the inheritance of acquired characteristics. Bertalanffy's home life was filled with social activity, as his family frequently entertained artists, singers, and scientists.[13]

He attended the University of Innsbruck and later the University of Vienna, although his wife, Maria, notes that he found the lectures boring. He was a frequent guest at the evening discussions of the Vienna circle, where he gained an appreciation for the limitations of logical positivism, particularly in its rejection of all questions of values, as well as its belief in empirical science as the only key to reality. For Bertalanffy, both theory and value were important components of the scientific enterprise. He met Maria in 1924 and they were married a year later. At the time he had just finished a paper on Oswald Spengler, whose interpretation of culture as an integrated system he applauded. He had also published essays on mysticism and modern art and literature, in addition to writing poems, plays, and a novel. With Maria's encouragement, he decided to pursue a career in biology and in 1926, with Moritz Schlick as his mentor, he completed his doctorate. Maria writes that Schlick "graciously" passed Bertalanffy's "abominable" dissertation on the problem of higher-order integration in the work of Gustav Fechner.[14]

In spite of their theoretical differences, Schlick nurtured Bertalanffy's interest in the epistemology of science. In addition, Austria had cultivated a long tradition of integrative thinkers to which Bertalanffy was heir. In his discussion of Bertalanffy's work, William Johnston describes two primary approaches to integrative thinking in Austria: the Leibnizians, with their emphasis on all-inclusive logical structures, and the impressionists, who sought to respect multiplicity and diversity while affirming an underlying unity. Bertalanffy appeals to this heritage in his affirmation of many levels of truth. After receiving his Ph.D. from the University of Vienna in 1926, he was docent, then professor, at the University of Vienna (1926–1948); professor and director of medical research at the University of Ottawa (1949–1954); director of biological research at Mount Sinai Hospital and visiting professor at the University of Southern California (1955–1958); professor of theoretical biology and member of the Center for Advanced Study in Theoretical Psychology at the University of Alberta, in Edmunton, Canada (1961–1969); and professor at the State University of New York at Buffalo (1969–1972). In addition, he was a fellow of the Rockefellor Foundation (1937–1938), a founding fellow of CASBS (1954–1955), and Alfred P. Sloan Visiting Professor at the Menninger Foundation (1958–1961). His academic work includes fourteen books and 250 monographs and articles.[15]

Bertalanffy's first paper on the organismic conception of biology appeared in 1926, and it was fully developed in his *Kritische Theorie der Formbildung,* published in 1928, affording him an international reputation. The basic outlines of the open-system concept and GST were already developed in this early discussion of the organism as a system, and the rest of his writings were devoted to working out these principles in greater detail. Building on Bertalanffy's work, Joseph Woodger, a member of the Theoretical Biology Group in England, published *Biological Principles* in 1929. Woodger translated *Kritische Theorie* into English in 1933, under the title *Modern Theories of Development: An Introduction to Theoretical Biology,* encouraging other members of the group to read the book. Joseph Needham, also a member of the Theoretical Biology Group, became an active advocate of the organismic approach. Alfred North Whitehead's "organic mechanism" was articulated in 1925 in *Science in the Modern World,* although his orientation was primarily philosophical, not specifically directed toward biological research, and did not influence European thought until later. Walter Cannon's concept of homeostasis, central to the development of cybernetics, was first elaborated in 1929.[16]

While experimental biologists were generally critical of the organismic conception, the idea found considerable support among morphologists and neurophysiologists. In his foreword to the 1961 edition of *Modern Theories of Development,* Bertalanffy points out that biology was primarily a descriptive science in the 1920s; theory was violently opposed as mere philosophy, metaphysics, and speculation. Rapoport argues that Bertalanffy's role in attempting to develop theoretical constructs and quantitative formulations should be acknowledged. His courses at the University of Vienna in the 1930s on quantitative biology and the physiochemical foundations of life were among the first of the kind, introducing Julian Huxley's work on allometry and D'Arcy Thompson's work on growth and form to the German academic community. He also played an important role in reorganizing the biological curriculum in medical education. Published in 1932, the first volume of Bertalanffy's *Theoretische Biologie* became one of the leading textbooks in Germany. Reviewing the book, Needham wrote, "Recognizing it as something new in biological literature, biologists everywhere . . . welcomed Bertalanffy's book, . . . for such a synthesis has never before been attempted." E. S. Russell, one of the earlier advocates of an organismic approach in England, wrote, "Bertalanffy is one of a small group of people who are paving the way to a new conception of the organism, a new orientation of biological thought."[17]

In 1937, on the recommendation of Nicholas Rashevsky, Bertalanffy received a Rockefeller fellowship to study developments in American biology. He presented his proposal for a general theory of systems to Charles Morris's philosophy seminar at the University of Chicago in the fall of that year, although he did not formally publish his ideas until after World War II. This presentation contributed to the inspiration for the Committee on the Behavioral Sciences that was established at Chicago in 1949 under the leadership of James Grier Miller. Bertalanffy spent part of that year at the Marine Biology Laboratory in Wood's Hole, Massachusetts, where he worked with Paul Weiss and T. H. Morgan. In 1938, after Hitler occupied Austria, the Rockefeller Foundation refused to renew his fellowship, arguing that funds were needed to support Jewish emigrés. Unable to find a position in the states, Bertalanffy returned to Vienna. Although he was critical of the Nazi regime and his biology was judged as "not in the proper 'nordic' style of Nazi science," he was allowed to continue his work.[18]

The war years were difficult for the Bertalanffys, who survived on care packages from Woodger, who sent what he could out of his own rations. During this period, Bertalanffy began to explore work in physical chemistry, leading to the development of his theory of open systems, first published in 1940. While he had started out primarily interested in developmental biology, his research interests shifted to comparative studies of growth and metabolism, which he thought would be more amenable to quantitative analysis. This interest was further developed in his work on malignant growth, which became the primary focus of his research throughout the 1950s. On the basis of this work, he was appointed as an honorary fellow in the International Academy of Cytology. In addition, he edited the *Handbuch der Biologie,* a fourteen-volume encyclopedia of the various fields of biology that Rapoport describes as "unique in international literature." Their home was burnt by the Nazis as they retreated from the Soviet troops at the end of the war, destroying much of Bertalanffy's work, including the third volume of *Theoretische Biologie* (the second volume was published in 1942). He and Maria went to Switzerland where, living in a small hostel, he continued work on *Das biologische Weltbild*. Published in 1949, and translated into English in 1951 as *Problems of Life,* it provided a comprehensive overview of open systems and his conception of general systems theory.[19]

After a brief appointment in England at the University of London Medical School, arranged by Woodger, Bertalanffy received an offer from the Lady David Foundation to go to Canada in 1949. As professor and director of research at the Medical Faculty at the University of Ottawa, he continued his research on quantitative metabolism and began his research on cancer. In 1953 he wrote to Aldous Huxley about his interest in establishing an institute for systems research, and Huxley encouraged him to submit a proposal to the Ford Foundation. In the same year he published an article on "Philosophy of Science in Scientific Education" that triggered Boulding's interest in his work, and resulted in an invitation to become one of the founding fellows of the CASBS. There he met Franz Alexander, also a CASBS fellow, whom he joined as codirector of psychosomatic medicine at the Mt. Sinai Hospital in Los Angeles from 1955 to 1958. Karl Menninger had been favorably impressed with Bertalanffy's work and offered him a position as visiting professor at his foundation in Topeka. By the 1960s Bertalanffy had become increasingly interested in the applications of systems ideas in the fields of psychology and psychiatry, and was awarded an honorary membership in the American Psychiatric Association for his contributions to a systems view of mental illness. In 1961 he joined the faculty of the University of Alberta in Edmunton, and in 1969 he went to SUNY Buffalo, where he stayed until his death in 1972.[20]

ORGANISMIC BIOLOGY

Bertalanffy's conception of organismic biology was rooted in his conviction that the characteristic phenomena of life, such as wholeness, organization, and regulation, should be amenable to scientific study. It evolved initially out of his interest in embryological development and expanded to encompass organic growth and evolution. He was concerned with the *anamorphic* nature of living processes (i.e., their tendency to develop increasingly complex forms, in opposition to the second law of thermodynamics). In addition, he emphasized the dynamic nature of organic processes and the hierarchical organization of living systems. These concerns were first laid out in *Modern Theories of Development* and are most comprehensively articulated in *Problems of Life*. He traces the evolution of the organismic perspective in philosophy to Nicolai Hartmann (1912), who advocated a system conception that would take into account interactions. He attributed Wolfgang Kohler with the first scientific attempt at incorporating such a perspective, in connection with his work in gestalt psychology (1924), which introduced the system concept of the organism and suggested that similar concepts would apply in other fields.[21]

In the beginning, Bertalanffy's interest in biology was focused on the debate between vitalists and mechanists regarding the nature of life. While mechanists argued that organic processes could be explained in terms of physics and chemistry, vitalists posited an immaterial organizing factor to account for the complex phenomena of life. Bertalanffy was particularly influenced by the work of vitalist Hans Driesch on developing sea urchins that challenged the reigning mechanistic theories of development. Based on his experiment in which the first four cells of a sea urchin embryo were divided in two and found to develop into two whole, though smaller, sea urchins, Driesch developed the concepts of equipotentiality and equifinality, meaning respectively that the embryonic cells, as they developed, were not bound by a predetermined program, and that the same final state could be reached from different starting points.[22]

Bertalanffy built on this concept of equifinality in his discussion of organisms as systems in a dynamic steady state. However, he rejected Driesch's appeal to an immaterial *entelechy* (organizing intelligence) that was not accessible to scientific study. Noting that vitalism and mechanism were both based upon a mechanistic model of living organisms in which living things are seen as basically inert, he thought his organismic view offered an alternative model that would overcome the dichotomy. In his view, the developing embryo is understood as a restless, dynamic flow, and "the developmental action of a cell depends on its position in the whole developmental system," which, beginning as a single cell, is progressively differentiated into subordinate systems.[23]

In articulating his organismic view, he describes organization as the essential feature distinguishing vital processes from ordinary physico-chemical processes. As a result, he argues that vital phenomena cannot be completely understood through an investigation of isolated parts and processes, as in the mechanistic approach, because it cannot explain the "co-ordination of the parts and processes in the complicated system of the living whole." "Thus," he writes, "the chief task of biology must be to discover the laws of biological systems to which the ingredient parts and processes are subordinate." Unlike vitalism, however, the organismic approach (or "system theory" of the organism) sought to explain such organization on the basis of forces immanent in the organism itself. Bertalanffy saw the organismic approach as complementary rather than antagonistic to the classical analytical approach. While he had gained an appreciation for the wholeness of vital phenomena from the vitalist perspective, he recognized its limitations and integrated mechanistic insights on the material basis of life in his work, which nevertheless was often dismissed as vitalistic.[24]

Bertalanffy argued further that his approach was not simply a compromise between the two positions, suggesting that the analytic, summative, and machine-theoretical conception of classical physics was the common foundation of both views. Based on early-twentieth-century developments in physics, he argued that this conception was obsolete: "Organization and wholeness considered as principles of order, immanent to organic systems, and accessible to scientific investigation, involve a basically new attitude." He quotes Arthur Eddington to confirm that his organismic conception was supported by development in contemporary physics: "We often think that when we have completed our study of *one* we know all about *two,* because 'two' is 'one and one.' We forget that we still have to make a study of 'and.' Secondary physics is the study of 'and'—that is to say, of organization."[25]

According to the classical statement of holism, the whole is greater than the sum of the parts. Bertalanffy argued that every organism was a system, which he defined as "a complex of elements in mutual interaction." In order to understand any system, he suggests, it is necessary to understand not only the parts, as in the mechanistic approach, but also the relations that exist between them. This was increasingly true even in physics, with the previously rigid structure of the atom now understood in dynamic and discontinuous terms. While the world view of the nineteenth century was primarily a physical one, Bertalanffy thought that an investigation of biological problems had essential contributions to make to the further evolution of science, and that the inclusion of such problems would lead to an expansion of the concepts and laws of physics. His organismic conception was thus an attempt to make the concept of biological wholeness scientifically meaningful.[26]

According to Bertalanffy, an organismic approach recognizes the hierarchical nature of organization in natural systems and requires investigation of phenomena at all levels, from the physico-chemical to the cellular, organismic, and even supra-individual level. Each level, he argues, is characterized by new properties and new laws, as well as by increasing degrees of freedom, allowing for the autonomy of life, as well as of biology as a science. He gives, as an example, the structural laws of organic molecules. Unlike simpler molecules, DNA possesses a dynamic structure that persists due to a pattern that is maintained in a steady state. Similarly, he suggests, higher organisms are more than simply a colony of cells; the action of the individual cells is determined by the whole organism through the three main integrative systems: circulatory, endocrine, and nervous. Along similar lines, principles of hierarchical organization were defined by Woodger, using mathematical logic to describe the way that subsystems are united at successive levels into higher and larger systems.[27]

Bertalanffy made a distinction, however, between physical systems, such as crystals, which were built from an aggregation of parts, and biological systems, which develop from a single undifferentiated whole into a highly differentiated and complex system, made up of several levels of subsystems. From this observation he derived a number of principles that characterized the process of differentiation in living systems: (1) progressive integration, as the parts become more dependent on the whole; (2) progressive differentiation, as the parts become more specialized; (3) progressive mechanization, meaning the loss of equipotentiality as the parts become fixed to a single function; and (4) increasing centralization, as certain parts gain predominace over others (such as the nucleus in the cell or the nervous system in higher animals).[28]

Similar processes were at work in the symbiotic relationship between animal and plant communities, according to Bertalanffy, who coined the term "biocoenosis" to refer to a "population system maintaining itself in dynamic equilibrium," a concept similar to Arthur Tansley's "ecosystem." Anticipating the Gaia hypothesis, he wrote that the whole of life on earth could be seen as the highest level of organization: "The stream of life is maintained only in continuous flow of matter through all groups of organisms. . . . Biological communities are systems of interacting components and thus display characteristic properties of systems, such as mutual interdependence, self-regulation, adaptation to disturbances, approach to states of equilibrium, etc." Of course he recognized that the degree of integration in biocoenoses is quite small in comparison with organisms; biological communities are far less centralized and determined far more by external conditions than are organisms. Neither ecological nor social systems should be considered as "superorganisms," but they could be understood as systems at an even higher level of organization, with their own unique laws and even greater degrees of freedom.[29]

With reference to Heraclitus and Nicholas of Cusa, Bertalanffy describes the dynamic process of biological organization as "a continuous struggle of parts." "The world as a whole, and each of its individual entities, is a unity of opposites, which, in their opposition and struggle, constitute and maintain a greater whole." In addition to its organization and dynamic nature, he also emphasized the historical character of life, which is most apparent in the developmental fields, such as embryology and developmental psychology, although it can be seen in the context of larger systems as well. He refers to Volterra's mathematical work on population dynamics, which could model systems with memory, in which behavior is dependent not only upon actual conditions, but also on previous history. In both developmental and evolutionary processes, Bertalanffy perceived the phenomenon of "anamorphosis," a tendency toward increasing order and greater complexity. He was critical of the emphasis in evolutionary theory on random and external factors (e.g., chance mutations and selective reproduction) as the only source of evolutionary change, which he saw as necessary but not sufficient conditions of evolution. Instead, he described evolution as a process codetermined by internal factors and organic laws.[30]

Chance and statistical probability tend to diminish differences in physical processes, while the evolution of biological forms has resulted in greater differentiation and complexity, which Bertalanffy suggested implies organizational forces similar to lattice forces in crystals, "forces of crystallization of a higher order." He pointed out that organizational forces are active in physics: "An atom or crystal is not the result of chance forces, but of organizational ones; yet it was thought possible to explain the organized things par excellence, the living organisms, as chance products of mutation and selection." He saw this emphasis on chance in evolution as a magnification of the economic principle of free competition into a "biologico-cosmological axiom," and described evolutionary theory as the "projection of the sociological situation of 19th and early 20th centuries into two billion years of the earth's history."[31]

In contrast to mechanistic theory, which tends to view the processes of life as purposeless and accidental, Bertalanffy emphasized the dynamic nature of evolution and the integrated nature of the genome as an organized system, suggesting that vital phenomena are the result of an ordered system and thus purposeful, not merely "a mess of aimless physico-chemical reactions." He suggested that the emerging science of genetics had provided a familiarity with the vocabulary but not the grammar of the genetic code. An understanding of the latter would require an integration of the concepts of organization and evolution that would take into account thermodynamics and information theory. Along these lines, Bertalanffy argued for the existence of regulatory genes as early as 1937. Further, he suggested that adaptation to environmental conditions, easily explained by the process of natural selection, was distinct from the evolution of more complex organizational forms, citing examples of convergent evolution in the similarity of eyes, as well as circulatory and nervous systems, in independent phylogenetic lines.[32]

For Bertalanffy, the emerging framework in theoretical biology reflected a fundamental change in the world picture. He saw his organismic model as an alternative to the reductionism inherent in the traditional approach to scientific research. In addition, it challenged the reigning scientism of the period—the idea that science, especially physics, provides the only legitimate approach to understanding reality. In addressing problems of wholeness and organization, he emphasized the heuristic value of theory in influencing the kinds of problems biologists might choose to investigate, as well as their experimental methodology—how they might frame their questions and explain the results of their research, with the ultimate aim of deriving exact laws that would explain biological phenomena.[33]

In his discussion of the organismic conception, Joseph Needham wrote: "Whatever the nature of organizing relations may be, they form the central problem of biology. The hierarchy of relations from the molecular structure of carbon compounds to the equilibrium of species and ecological wholes will perhaps be the leading ideas of the future." The importance of organismic approaches in biology resurfaced in the 1960s, with the revival of discussions of reductionism that accompanied the emergence of molecular biology, particularly in the work of René Dubos, Theodore Dobzhansky, and Barry Commoner, although they did not refer to Bertalanffy's work. In general, he has been accorded greater recognition in Europe and the former Soviet Union than in the United States.[34]

The most significant aspect of the organismic model, in Bertalanffy's mind, was its challenge to "the machine theory of life," which he described as "the perfect expression of the *zeitgeist* of an epoch which, proud of its technological mastery of inanimate nature, also regarded living beings as machines." Echoing similar sentiments, Aldous Huxley wrote to his brother Julian, after reading Bertalanffy's *Problems of Life:* "How paradoxical it is that when life develops organizations complex enough to be capable of thought, the emergent mind should revert, in its always oversimplified abstractions and generalizations, to patterns of symbols comparable in their subtlety and complexity only to organizations in the physical world and not to those in the living universe. . . . Hence, of course, the mess in which we find ourselves."

In contrast to the machine theory of the organism, Bertalanffy emphasized the active nature of the organism, based on his understanding of organisms as open systems, one of his most important contributions to the field of psychology and central to his conception of general systems theory.[35]

OPEN SYSTEMS

Bertalanffy's conception of open systems emerged in conjunction with his work on the comparative physiology of metabolism and growth during the 1930s, developing mathematical equations to predict rates of growth in different species based on metabolic rates. The principle of allometry, or relative growth, formulated by Julian Huxley in 1924, provided the foundation for this work. In examining the relationships between metabolism, body weight, and surface area, Bertalanffy identified different morphological types, based on whether respiration was weight- or surface-proportional. In most species, the metabolic rate increases in proportion to surface area.[36]

Bertalanffy considered growth to be one of the fundamental problems in biology. His insight was to generalize mathematically the basic idea that growth results from the interaction between anabolism and catabolism, the continuous processes of building up and breaking down that he considered fundamental to all aspects of life. While anabolism is related to metabolism and respiration and thus dependent on the shape and surface area of the body, catabolism is dependent upon body weight. Since surface area decreases relative to volume with increasing size, there is a natural tendency for organisms to stop growing as they reach a certain characteristic size where anabolic and catabolic processes exactly balance each other in a steady state. This principle also applies to the relative growth of different body parts. In humans, for example, the head grows more slowly than the arms or legs. From these considerations, Bertalanffy developed a quantitative theory of dynamic morphology. His growth equations applied to numerous types of growth curves and have been particularly influential in fisheries management.[37]

The concept of the organism as an open system follows from this understanding of the dynamic nature of organic structure in the self-regulating balance between assimilation and decomposition. In contrast to the Apollonian ideal of static repose, which he felt characterized the world view of classical physics, Bertalanffy appealed to Heraclitus's conception of reality as a ceaseless stream of events: "We ourselves are not the same from one moment to the next." While the organism is apparently persistent, it is really the manifestation of a perpetual flow, an *open system* in a dynamic steady state. The organism is never in a state of equilibrium, and maintains itself in a nonequilibrium state by taking in a continuous supply of energy and exchanging components with its environment. Bertalanffy's mathematical formulation of such nonequilibrium thermodynamics was one of his most important contributions.[38]

The second law of thermodynamics implies that physical interactions should proceed toward the least-ordered state, characterized by maximum entropy, minimization of differences, and equilibrium. In stark contrast, the evolutionary phenomena of life manifest increasingly complex and highly ordered forms, decreasing entropy, and greater heterogeneity. Bertalanffy pointed out that the second law applies only to closed systems, which had been the primary focus of physics. Far from contradicting the principle of thermodynamics, he thought the phenomena of life required an expansion of traditional thermodynamics, of which closed systems were only a special and very limited case. Ilya Prigogine's work on irreversible thermodynamics in the 1940s provided a further working out of this concept in the field of chemistry. Bertalanffy noted that information, as a measure of order in a system, has the same mathematical formulation as negative entropy, although he also acknowledged that the relationship between information, organization, and thermodynamics was not clear and that applications of information theory in biology had generally not proven fruitful.[39]

Linking the open-system concept with the idea of hierarchicial levels of organization, Bertalanffy defined the living organism as "a hierarchy of open systems maintaining itself in steady state due to inherent system conditions." The open-system nature of life accounted for its equifinality (the idea that the same final state could be reached from different starting points), the characteristic steady state for each organism being determined by the systemic organizational forces that balanced inflow and outflow. Overcoming the separation between morphology and physiology, which was based on a static conception of the organism, Bertalanffy described organic structure as "slow processes of long duration" and organic function as "quick processes of short duration." He thought that this "system conception" of the organism provided a foundation for exact quantitative laws for biological phenomena. In addition, it emphasized the inherently active nature of organic systems.[40]

J. D. Bernal, a member of the Theoretical Biology Group in England, acknowledged the significance of the open-system theory. Arthur Koestler, as well, wrote that the concepts of hierarchical organization and open systems were central to the future of biology. In addition, Bertalanffy discussed the relevance of the concept in ecology, particularly in connection with the work of Alfred Lotka and Vito Volterra on population dynamics, which provided some of the inspiration for his own work. He also identified similar conceptual developments in transactional philosophy, econometrics, and Lewis Richardson's work on arms races. Daniel Katz and Robert Kahn applied the concept in their classic work on social psychology, as did Richard Scott in his discussion of organization theory. One of the most significant applications was in the theory of the personality as an open system.[41]

GENERAL SYSTEM(S) THEORY

In positing general system theory as a comprehensive theoretical framework, Bertalanffy saw it as arising out of a growing tendency toward integration in both natural and social sciences, centered around the concept of systems, which Russell Ackoff identifies as a "key concept in scientific research" during the 1940s and 1950s. Although systems had been studied for centuries, Ackoff suggests that "open[ing] interactions for examination" and "examin[ing] larger and larger slices of nature" constitutes a new approach, which he describes as "probably the most comprehensive effort to attain a synthesis of scientific knowledge yet made." The general aim of Bertalanffy's approach was to determine principles that applied to systems in general, to classify logically different types of systems, and to work out mathematical models for describing them, with the ultimate aim of unifying science. Translating from the German, he originally spoke in terms of general *system* theory, although the plural form is more common in the general-systems literature.[42]

Bertalanffy noted that his general-systems approach was often criticized as reinvoking metaphysics, since questions of wholeness were considered unscientific or vitalistic. He attributed this to the epistemological bias rooted in mechanistic science, which he claims never eliminated metaphysics, since any theory of wider scope always implies a more extensive world view. He suggested that the metaphysics of positivism, inherent in the mechanistic world view, was "particularly naive and superficial." Further, he constantly argued that the mechanistic view was rooted in a utilitarian conception, "deeply connected with the economic outlook of the 19th and early 20th centuries," that reinforced the Hobbesian view of society as the war of all against all. Basic conceptions of mechanistic science, such as strict causality, the summative and random character of natural events, and the assumption of linear relationships and minimum interaction between parts, were in his eyes inadequate to explain emerging problems in a wide range of disciplines. Noting Thomas Kuhn's model of scientific revolutions, Bertalanffy saw GST as a new paradigm that was being elaborated, to some extent mathematically in terms of nonlinear differential equations, but also in terms of verbal formulations, since he recognized that there are clearly aspects of reality to which the language of mathematics does not apply. The most significant aspect of this new paradigm, in his eyes, was that it offered a new world outlook or philosophy.[43]

While he presented the general outline of his general-systems conception at the University of Chicago in 1937, he did not present the idea to a wider audience until 1948 at the Alpbach Symposium. He acknowledges Lotka's 1925 work on population dynamics as the original precursor to the idea of a general systems theory. In addition, he mentions Dewey's emphasis on including the environment in any study of the organism, as well as his work on the relationship between the organism/environment and the observer. Bertalanffy also acknowledges the contributions of Ashby and Wiener, although he points out that the concept of feedback had been advanced in the 1920s. Looking back on the evolution of the systems concept in 1962, he writes, "In spite of obvious limitations, different approaches and legitimate criticism, few would deny the legitimacy and fertility of the interdisciplinary systems approach."[44]

Bertalanffy describes the fields of cybernetics, systems engineering, and systems analysis as arising out of the complexities of modern technology. Although he recognizes a connection between GST and the technological fields, his emphasis is on the need for a conceptual framework that transcends the mechanistic foundation of classical science in order to address the more complex phenomena that characterize the biological, behavioral, and social sciences. He cites Warren Weaver's distinction between classical physics, which deals with simple systems; probability, which deals with unorganized complexity; and the new science of systems, which deals with organized complexity. Rather than positing an all-encompassing world system, he conceives of GST as a working hypothesis. Introducing his epistemological conception of "perspectivism," in contrast to the reductionism of classical science, he stresses that all scientific constructs are models representing only certain aspects or perspectives of reality, and that other perspectives are both valid and necessary, including myth, poetry, and philosophy. In his words, "every model becomes dangerous only when it commits the 'nothing-but' fallacy."[45]

Bertalanffy thought that his organismic conception of systems could provide a richer and more comprehensive understanding of complex systems than elementary methods of analysis, which were inadequate in such contexts. However, he acknowledged that it could never be exhaustive, exclusive, or final. More important than any single application was the change in the frame of reference that allowed investigators to see problems previously overlooked or to see them in a new light. Conceding that systems theory might not be able to supply a set of overall principles, Carl Hempel suggests that "it is well possible that the general mode of approach advocated by von Bertalanffy will prove a highly useful heuristic guide in the search for the solution of specific theoretical problems."[46]

Describing theoretical and mathematical models as both necessary and limited, Bertalanffy thought GST provided models that were dynamic rather than static, molar rather than molecular, and formal rather than material. Suggesting that similar concepts and models were emerging in widely diverse fields, he saw GST as an effort to discover universal patterns of organization, at the same time acknowledging that unique emergent qualities existed at each level of organization, and thereby seeking to distinguish between principles that were common to all levels and those that were specific to the individual levels. Thus he emphasized that the organismic conception did not imply the "unilateral dominance of biological conceptions," but rather highlighted the autonomy of different levels. Reflecting on the development of GST, he acknowledged that formal models were oversimplifications and that there were often incongruities between models and reality, although he still believed that they could provide an important contribution toward conceptual mastery of nature and the expansion of scientific theory. At the same time, he saw a danger in some of the later developments. While science had previously been dominated by a narrow empiricism and theory had been equated with speculation, the growing enthusiasm for model building had led to overextended expectations and a lack of regard for empirical fact.[47]

Questions relating to the nature of wholeness, organization, and dynamic multivariate interaction characterize organized systems at all different levels, where the behavior of the parts is different when studied in isolation than when in the context of the whole. The study of these systems, Bertalanffy suggests, would focus on such principles as growth, regulation, hierarchical order, equifinality, progressive differentiation, progressive mechanization, progressive centralization, closed and open systems, competition, evolution toward higher organization, teleology, and goal-directedness. Arthur Koestler suggested, for example, that progressive differentiation could be seen in psychology, embryology, the nervous system, cognition, and sociological phenomena. Bertalanffy thought these concepts could provide a foundation for interdisciplinary synthesis and contribute to the unification and integration of science within a broader framework than the reduction of all sciences to the mechanistic conceptions of physics. Further, he thought it would facilitate a more integrated approach to education that would include ethical values and the development of the personality.[48]

In discussing the relationship between his own "organismic" approach to studying complex systems and the related fields of systems engineering, systems analysis, and operations research, Bertalanffy saw the latter as having a narrower focus. Nevertheless, he recognized the contributions of these fields in the evolution of the modern systems movement. At the same time, he thought it was essential to distinguish between the nature of processes in technological systems and those in biological and social systems, where the parts and processes were organized in view of the maintenance, development, and evolution of the system. This distinction is at the root of his identification of two distinct strands of systems thought: (1) mechanistic, focused on technological and industrial developments such as control techniques, automation, and computerization; and (2) organismic, focusing instead on the principles and laws concerning the organization of living organisms. Nevertheless, developments in both strands were highly interdisciplinary, drawing on many of the same theoretical frameworks and mutually shaping each other.[49]

Highlighting the significance of his distinction, Bertalanffy wrote, "The mechanistic world view found its expression in a civilization glorifying physical technology which eventually has led to the catastrophies of our time. Possibly the model of the world as a great organization can help to reinforce the sense of reverence for the living which we have almost lost." Echoing this sentiment, William Gray, a psychiatrist who drew extensively from Bertalanffy's work, argues that there were profound differences between the pragmatic/mechanistic approaches to systems theory and the humanistic/organismic systems approach advocated by Bertalanffy. While the first emerged in response to the needs of science and technology without regard for human values, he suggests that general systems theory offered the hope of reincorporating the human element.[50]

CYBERNETICS AND GST: MECHANISTIC VERSUS ORGANISMIC MODELS

Cybernetics and GST are generally equated in contemporary discussions of systems theory. Bertalanffy, however, wrote at length about the differences in basic assumptions and general orientations between the two approaches. Since it emphasized feedback as the primary mode of regulation, he suggested that cybernetics was only one of many principles that applied to systems in general, and that there were other kinds of regulation that were inherent in the system itself and not dependent on input from the environment. Further, and most importantly, he saw cybernetics as merely an extension rather than a replacement of the machine model central to the mechanistic framework.[51]

These characterizations are not entirely accurate, as the field of cybernetics evolved to incorporate many of the same elements that Bertalanffy thought were unique to his system. Drawing on concepts from cybernetics, Gregory Bateson emphasized the active nature of mind, for example, in *Steps to an Ecology of Mind.* Nevertheless, Bertalanffy distinguished between the two approaches on the basis of their organizing concepts: feedback and homeostasis in cybernetics and open systems and dynamic interactions in GST. While cybernetics tends to emphasize equilibrium models, GST is based on the idea of systems in nonequilibrium states. According to Bertalanffy, the cybernetic model, which he describes as "stimulus-response with a feedback loop," represents the organism as essentially reactive, unlike the organismic model of GST, which portrays the organism as fundamentally active. GST emphasizes process and function in contrast to the cybernetic emphasis on homeostasis and structure. Although cybernetics highlights the concepts of information and communication, his open-system model emphasizes the dynamic interaction of components based on generalized kinetics and thermodynamics. Unlike the mechanistic view, which emphasizes structural or "machine" conditions, Bertalanffy thought his approach was nonmechanistic in understanding regulative behavior as an active interplay of forces.[52]

Although Ross Ashby used many of the same mathematical models in the elaboration of his conception of cybernetics, Bertalanffy objected to his basic definition of a system as "a machine with input," because it only applied to closed systems. Machines are incapable of self-organization in the sense of making automatic changes in organization; all such changes must come from an outside agent.

While feedback provides a foundation for purposive behavior in machines as well as in living organisms and social systems, Bertalanffy argues that the concepts of equilibrium and homeostasis cannot account for the phenomena of change, differentiation, evolution, emergence, creativity, and self-realization characteristic of living systems and human beings. In addition, he notes that the feedback concept emphasizes the exchange of information, while the open-system model focuses on the exchange of matter/energy and entropy. Unlike open systems, which actively tend toward states of higher organization, feedback systems can only reach such higher states reactively, on the basis of information fed into the system. He acknowledges, however, that adaptation and evolution are related to an increase in information, pointing to the relation between irreversible thermodynamics and information as an important area for further research. Significantly, the formulas for information and negative entropy are mathematically equivalent or *isomorphic,* and such isomorphic relationships form the basis for further research in the general-systems tradition.[53]

MATHEMATICS AND ISOMORPHIC RELATIONSHIPS

Bertalanffy described GST as a logico-mathematical discipline, similar to probability theory, with applications in diverse fields. At the same time, he acknowledged that there were aspects of organization in complex systems, such as hierarchical order, that did not lend themselves to quantification. Bertalanffy suggested, however, that contemporary developments in such areas as topology, set theory, and factor analysis could allow for formal description of complex phenomena that were not quantifiable in the traditional sense. His initial efforts in GST were articulated in terms of differential equations, which Davidson describes as the mathematics of movement, growth, and change, in order to model the dynamic behavior of open systems. With the evolution of computer technology came the ability to simulate systems of complex relationships.[54]

Differential equations describe change in one variable in relation to changes in other variables. Systems of differential equations are commonly used to describe the behavior of complex systems. Because each aspect of the system changes in response to changes in other aspects, these systems of equations provide a means of modeling feedback phenomena. When the relationships between variables are nonlinear, analysis of the system is extremely difficult using the tools of traditional mathematics. Much of the early work in systems analysis (operations research, linear programming, etc.) was based on systems of linear differential equations, with the aim of optimizing specific variables. Computers allowed researchers to simulate the behavior of nonlinear systems, which characterize the phenomena of life. Bertalanffy gives as an example the fourteen-step reaction chain of glycolysis, which can be described in terms of one hundred nonlinear differential equations. Similar analyses have been applied to economic systems. Perhaps the most ambitious application of computer simulation was the well-known study *Limits to Growth,* modeling the relationships between population, technology, resources, and pollution.[55]

While these techniques have been widely criticized, they do provide a heuristic device for exploring the potential impact of different kinds of changes in complex systems that often turn out to be counterintuitive, illustrating, for example, the relative stability or instability of the system, as well as the potential for cyclical or periodic fluctuations (or, in *Limits to Growth,* of the potential for "overshoot" and collapse). Bertalanffy himself cautioned against excessive reliance on formal models without empirical verification. His own studies on growth were based on extensive laboratory work. All models, he suggests, are simplifications and abstractions. And, further, all laws are statistical (i.e., they can predict the probability but not the inevitability of events), particularly in systems at higher levels of organization, where there is greater potential for creativity and emergent phenomena. Even physics, he notes, had to give up the ideal of exact laws for statistical formulations. However, he did believe that it was possible to identify characteristic patterns of behavior using mathematical analysis.[56]

Bertalanffy considered population dynamics to be one of the most advanced fields of quantitative biology, in reference to the work of R. A. Fisher, J.B.S. Haldane, W. Ludwig, and Sewall Wright on the mathematical analysis of selection. Emphasizing the autonomy of laws at different levels of reality, he pointed out that the development of chemistry as a science required the elaboration of new constructs and laws. Similarly, he hoped to contribute to the development of appropriate theoretical abstractions and the formalization of biological principles beyond the primarily descriptive nature of biology. At the same time, he acknowledged that many of the essential questions of biology are not strictly quantitative, but instead deal with issues of pattern, position, and shape. Further, he suggested that purely qualitative models are also important, as in Darwin's theory of evolution or Freud's work on psychoanalysis.[57]

Robert Rosen, a mathematical biologist working along similar lines, argues that mathematical thought is really about patterns, and that the narrow identification of mathematics with computability excludes almost all of mathematics. He met Bertalanffy while working at the Center for Theoretical Biology at the State University of New York in Buffalo. He had studied mathematical biophysics with Nicholas Rashevsky at the University of Chicago in the 1950s, which, at the time, had the strongest mathematics department in the country. Rapoport was also a student of Rashevsky's and both were active participants in the Committee on Mathematical Biology. Rosen suggests that Rashevsky's work on networks and automata theory paralleled Bertalanffy's work on open systems. Rosen himself was interested in the relationships between formal mathematical models in different fields, describing such models as "abstract patterns of functional organization." He argued against the prevailing belief that mathematics and life were somehow incommensurable, but his work, like Bertalanffy's, was rejected by most biologists; his *Dynamical System Theory in Biology,* he says, met with virulent hostility.[58]

Bertalanffy's efforts to articulate isomorphic relationships in the behavior of different types of systems was perhaps the most controversial aspect of GST. He contrasted *homologies,* or structural similarities in the patterns of organization, with superficial *analogies,* in which there is no correspondence between either causal factors or relevant laws, suggesting that the tools of GST might provide a way of distinguishing between the two. In homologous systems, although the efficient causes of behavior in each system might be different, the formal laws describing them are identical. In addition to the example of the homology between information and negative entropy mentioned above, Bertalanffy identifies several examples of homologous principles. The example he appealed to most frequently is the similarity in equations describing the flows of electricity and heat. Another common example is the similarity between the models and equations describing equilibria in chemical kinetics, econometrics, and population dynamics, the second being a special case of the latter, resulting from similar relations of competition between different individuals. Business cycles and population fluctuations thus result from similar conditions of competition and interaction in the respective systems. His primary example of a meaningless analogy was the common description of the state as an organism, which, he wrote, provided the foundation for totalitarianism.[59]

Further examples of such homologous principles include the exponential law of natural growth, logistical law (describing exponential growth limited by some restricting conditions), the law of allometry (relative growth of components within a system), kinetic principles, the principle of least action, oscillations, periodicity, and Pareto's law regarding the distribution of income. As an example of a generalizable principle, he argued that the law of allometry, or relative growth, could be applied as a quantitative law to business organizations, as well as to the processes of urbanization and social differentiation. At the same time, he acknowledged the importance of nonquantitative laws, such as those Boulding addressed in *The Organizational Revolution* regarding optimum size for organizations (based on D'Arcy Thompson's principles), as well as the Malthusian law of population growth, the laws of economic cycles, and oligopoly. In his early work, he mentions the conformity among principles of regulation in embryonic development, in regeneration, in the distribution of excitation in the nervous system, and in gestalt perception. In response to criticism of such wide-ranging use of analogy, Bertalanffy compared the system concept with the law of gravity, arguing that Newton's synthesis was based on his perception of an analogy between the behavior of apples, planets, and tides. For him, the system concept was similar to such concepts as mass, acceleration, and energy.[60]

TOWARD A NEW IMAGE OF HUMANITY: GST IN PSYCHOLOGY AND SOCIAL SCIENCE

Whether or not there is a truly "homologous" relationship between open systems in the biological and behavioral sciences, the concept of the open system had a profound impact on the latter. This was particularly true in the fields of psychology and psychiatry, where Bertalanffy's elaboration of the concept provided a solid theoretical foundation. Based upon his organismic conception of the living organism as fundamentally active, Bertalanffy proposed an organismic theory of the personality, challenging what he saw as the “robot model” of the dominant behaviorist view.[61]

Similarly, he challenged the equilibrium model that was central to most functionalist sociology, emphasizing, as he had in biology, the importance of developmental and evolutionary change, which in social systems depends upon the creativity and spontaneity of individual human beings. While he recognized the need for a more sophisticated understanding of social systems, he was violently opposed to the idea of a scientifically controlled society. Rather, he suggests,

> We may . . . conceive of a scientific understanding of human society and its laws in a somewhat different and more modest way. The real values of humanity . . . are those which stem from the individual mind. Human society is not a community of ants . . . controlled by the laws of the superordinate whole; it is based upon the achievements of the individual, and is doomed if the individual is made a mere cog in the social machine. The Leviathan of organization must not swallow the individual without sealing its own inevitable doom.[62]

Bertalanffy acknowledged that the system concept was problematic, since the term itself seemed to be associated with “everything that is undesirable in the present world.” Clearly, the technological approach to planning in the mechanized and highly differentiated society of the twentieth century tended to devalue the individual. In this sense, systems analysis had contributed to the enslavement and alienation of humanity. He argued, however, that the lack of an adequate image of the human being had contributed to the crisis, and his efforts to elaborate a “humanistic” systems view of “man” illustrate his attempt to address these concerns.[63]

Bertalanffy aligned himself with the gestalt and humanistic traditions in psychology, represented in the work of Kurt Lewin, Heinz Werner, Jean Piaget, and Abraham Maslow. Both of these approaches were rooted in an organismic and developmental view of the personality, emphasizing the processes of individuation, emergence, differentiation, growth, and learning, while rejecting deterministic views that emphasized instincts, reflexes, and conditioned responses. Although Bertalanffy was not responsible for introducing the organismic viewpoint in psychology, his research in biology provided a more substantial foundation for the evolution of the organismic approach. Nicholas Rizzo points out that William James was unsuccessful in his attempts to develop a more holistic approach in psychology because he lacked an organismic biological framework, and he praises the richness of GST as a conceptual framework for a more integrated study of clinical and social problems as well as the institutions that create them.[64]

William Gray argues that the basic ideas of anamorphosis and open systems were vital to psychiatry and rejuvenated its approach. Most significant was the concept of human beings as organic systems whose relationships with the larger systems within which they exist (physical, social, economic, and cultural) determine their mental health. This insight was responsible for the development of family and group therapy that allowed for much more effective treatment of certain psychological disorders. Gray remarks that the goal of many systems theorists to optimize system function without regard for the psychological implications of their actions is doomed to failure, arguing instead that humanistic values must be included in systems plans. Reinforcing these themes, Viktor Frankl writes that "if you conceive of man in terms of a closed system, you notice only forces that push but no motives that pull." While the objectification of human existence in behaviorist approaches opened the door to manipulation, Bertalanffy's conception of humanity emphasized the openness of existence, the possibility for self-transcendence, and the central importance of meaning and values.[65]

As a result of his work in this field, Bertalanffy was invited in 1956 to participate in a research group on child development sponsored by the World Health Organization. He was elected in 1967 as an honorary fellow of the American Psychiatric Association. Karl Menninger wrote that he considered Bertalanffy to be one of his most influential teachers. With Pitirim Sorokin and Abraham Maslow, he founded the International Center for Integrative Studies, a reflection of his broadly interdisciplinary interests and his concern with the trend toward overspecialization and fragmentation, which is also highlighted in Boulding's emphasis on the importance of GST as an integrative force in the social sciences. The systems concept had a profound impact on the social sciences, although Talcott Parsons, whose work emphasized homeostasis and equilibrium concepts, essentially defined systems theory in sociology, eclipsing the more dynamic elements of Bertalanffy's approach.[66]

BEYOND THE ROBOT IMAGE

The fundamental characteristic of Bertalanffy's image of the human being as an open system was its dynamic, creative, and inner-directed activity. This was in stark contrast to theories that emphasized passive response and the maintenance of homeostasis: "If the principle of homeostatic maintenance is taken as a golden rule of behavior, the so-called well-adjusted individual will be the ultimate goal, this is a well-oiled robot maintaining itself in optimal biological, psychological, and social homeostasis." Bertalanffy believed that the dominance of the stimulus-response scheme in psychology was connected with the "zeitgeist of a highly mechanized society" and argued further that the behaviorist model ignored the essential realms of play, exploratory activity, creativity, and self-realization, which were not encompassed by the principle of utility. In his view, internal activity was primary and the process of stimulus and response was a regulative mechanism that was superimposed upon it.[67]

This emphasis on the fundamental nature of internal activity grew out of Bertalanffy's conception of the organism as an open system capable of maintaining itself in a far-from-equilibrium state. As a result, he argued that the principle of homeostasis, which emphasized the tendency toward equilibrium, was inadequate to explain behavior. He thought the conception of the organism as primarily reactive was retained in the cybernetic view and in images of the brain as a computer.

Although Gray describes Freud as a great system thinker, Bertalanffy rejected his view of human behavior as driven by the desire to eliminate tensions and achieve stability, arguing that rest and inactivity were not the ultimate goals of human behavior.[68]

The tendency to explain behavior exclusively in utilitarian terms echoes the economic concern of commercial society with maximizing gain and minimizing expense. In Bertalanffy's view, this model justifies the massive efforts in behavioral engineering, reflected in media and advertising campaigns, that are required to grease the wheels of free enterprise: "Only by manipulating humans ever more into Skinnerian rats, robots, buying automata, homeostatically adjusted conformers and opportunists, can this great society follow its progress toward ever increasing gross national product." He argued that behaviorist psychology provided techniques for turning human beings into subhuman automata, quoting Arthur Koestler, who commented that "for the anthropomorphic view of the rat, American psychology has traded in a rattomorphic view of man." By manipulating individuals on the basis of Pavlovian and Skinnerian principles, psychologists actually achieved a sort of functional decerebralization.[69]

Bertalanffy described psychology as "a social force of the first order," responsible for molding humanity's self-image, manipulating individual motivations, and reinforcing conformity and opportunism as ultimate values. In his view of psychology as the "handmaiden of pecuniary and political interests," he drew on Vance Packard's discussion, in *The Hidden Persuaders,* of the role of advertising in commercial society. Conditioning techniques reinforced a debasing image of humanity, which encouraged people to treat each other as objects to be manipulated rather than unique individuals to be treated with respect. Moreover, the emphasis on material well-being that characterized modern society, far from achieving "the greatest happiness of the greatest number," had resulted in increasing social disintegration and mental illness. He pointed out that mental illness is characterized by an impairment of spontaneity, which he attributed to the other-directedness of modern society.[70]

The concept of the organism as fundamentally autonomous represented to Bertalanffy a complete revision of the principle of homeostasis that characterized the robot model of humanity. He identified Heinz Werner's organic developmental approach to psychology in the 1920s as one of the first to overcome the dominant positivistic and mechanistic orientation of behaviorism and to lay the groundwork for a new and more dignified image of humankind. This new image was based on the concept of the personality as an active system, which was further developed in the work of Gordon Allport, Abraham Maslow, and Jean Piaget, and emphasized the creative and self-transcendent dimensions of human existence. An important aspect of this new image was the emphasis on the importance of culture, along with a recognition of the systemic character of both personality and culture.[71]

CULTURE: THE SYMBOLIC DIMENSION

Bertalanffy described the symbolic dimension of culture as an emergent property unique to human society that could not be reduced to biological drives, suggesting that "symbolic universes" are the most important part of the individual's behavioral system. While it is questionable whether humans are truly rational creatures, they are certainly "symbol-creating and symbol-dominated." Humans are thus creatures of two worlds, as biological organisms living in a universe of symbols. Mental disturbance is thus a specifically human phenomenon that is culturally dependent, resulting from a disturbance of symbolic functions. In contrast, mental health can be defined as the possession of an integrated symbolic universe consistent within a given cultural framework. Bertalanffy pointed out that the "unreasoning" behavior of animals is often more "rational" than that of humans, who are being increasingly influenced toward irrational choices by media and the advertising industry.[72]

Human behavior is embedded within a cultural system and shaped in relation to specific goals, the understanding of which is connected with the evolution of language. Bertalanffy argues that human motivation should not be modeled after motivation in animals, since the symbolic dimension of culture introduces elements of purposiveness and intentionality into human behavior, resulting from efforts to realize certain values. As an example, he points to large-scale human aggression in warfare, which, he suggests, nearly always has symbolic roots. In the same way that biological systems are relatively autonomous with respect to inanimate nature, symbolic systems are relatively autonomous with respect to biology.[73]

As a result, Bertalanffy's "new image" of humanity incorporated an appreciation of the role of symbolism, values, and ethics: "In the last resort . . . it is always a system of values, of ideas, of ideologies that is decisive." He saw values as culturally determined and objected to the naturalistic view of humankind that reduced values to biological needs, drives, and principles. He also rejected the utilitarian conception of pleasure as the ultimate good, because he thought it would tend to foster an emphasis on homeostasis, adjustment, and adaptation, and reinforce a philosophy of conformity and the preservation of the status quo as the ultimate goal. The same criticism was later brought against Talcott Parson's social-system theory, undermining support for systems perspectives in sociology. Bertalanffy himself discussed the limitations of functionalism in terms of its overemphasis on maintenance, equilibrium, adjustment, homeostasis, and stable institutional structures, as well as its failure to consider history, process, change, and inner-directed development. For Bertalanffy, the pursuit of happiness involved "the full realization of one's own potentialities" rather than adaptation, adjustment, and the release of tensions.[74]

This new image of humanity is rooted in Bertalanffy's conception of cognition as an active process, in contrast to what he called the "dogma of immaculate perception," portraying the organism as a passive receiver of stimuli from the environment, a "latter-day version of Locke's tabula rasa." Instead, he argues that the organism creates the world around it, citing the work of Jean Piaget, Heinz Werner, Ernest Schachtel, and the "New Look" in perception theory, on the importance of attitudes, emotions, and motivations in shaping perception, along with the discoveries of Benjamin Whorf and Wilhelm von Humboldt in connection with the role of language in the formation of experience. Anticipating postmodern perspectives, he wrote that every symbolic world, including science, is "a construct determined by innumerable factors of biological, anthropological, linguistic, and historical nature," suggesting further that classical Western science represents only one of many possible approaches to understanding reality.[75]

Referring to Werner Heisenberg's discoveries on the interaction between the observer and the observed, Bertalanffy suggested that the systems concept required a new epistemology and a shift from an "absolutistic" to a "perspective" philosophy. Traditional psychological theory had been founded on what he considered an obsolete belief in the Cartesian dualism of mind and body, itself rooted in a naive realism. With recent discoveries in physics, matter was "dematerialized," at the same time that mind was being "dementalized." The perception of "things" was dependent upon previous experience, learning processes, emotional-motivational factors, and symbolic-linguistic factors, "without which," argued Bertalanffy, "clear-cut objects and the experiencing ego simply wouldn't exist." The breakdown in the dualism between mind and matter paralleled a breakdown in the separation between subject and object as well as that between the self and the external world.[76]

In addressing the mind-body problem, Bertalanffy suggested that one of the key questions was "whether we should take the world outlook of the Western adult for granted, and dismiss all others as primitive superstition." He saw the mind-body problem as an illusion that reflected the idea of the self as totally separate from the external world, itself culturally evolved. He wrote that the perception of separation between the self and the world was the result of a long process, including biological evolution, cultural and linguistic history, as well as the mental development of the child. He considered the ego boundary to be both fundamental and precarious, and yet, like all boundaries, "ultimately dynamic." As a result, he emphasized the importance of considering the interactions between individual and environment, as well as the interactions between biological and psychological dimensions of human behavior.[77]

The nature of the relationship between the individual and the society as a whole was central to Bertalanffy's consideration of values. He argued that social systems require different moral concepts from those that apply to individual behavior, and that an appropriate value system for complex social systems has not yet evolved. Instead, the individual is "entangled, controlled, and governed . . . by impersonal and often immoral social forces." He thought moral codes should be expanded to include larger social entities in order to "safeguard the individual from being devoured by the social Leviathan." While systems analysis contributed to the development of high levels of rationality in means, it often reinforced complete irrationality in terms of the goals it served. Bertalanffy hoped to expand the contributions of systems analysis to include questions of meaning, which he saw in terms of interconnections within a system.[78]

The failure of most systems approaches to consider such questions of meaning results from the Cartesian separation of matter and mind, which reflects only a limited perspective on the "real world," according to Bertalanffy. He argued that the tendency to interpret symbolism solely in terms of communication was overly simplistic, leaving out critical considerations of both meaning and structure. He hoped to foster the development of a more humanistic science that would address human concerns as it sought more comprehensive conceptual models of reality. In his view, there was no fundamental antithesis between science and the humanities, although such a conflict emerged with *scientism,* which he described as a "devaluation of science and an intrusion of scientific ways of thinking into fields where they do not belong" and a "positivistic, technological, behavioristic and commercialistic philosophy which devalues man into a robot and handles him accordingly." For Bertalanffy, science should be "more than an accumulation of facts and technological exploitation of knowledge in the service of the Establishment." His conception of GST thus includes a concern with fostering social systems that serve the needs of their individual human members, and with developing technology in harmony with human values.[79]

CRITIQUES OF BERTALANFFY AND GST

In light of these views, it is ironic that Bertalanffy is often associated with and held responsible for the many abuses of systems analysis in government and industry. Two of the most comprehensive critiques of the systems approach in the social sciences were Ida Hoos, *Systems Analysis in Public Policy: A Critique* (1972), and Robert Lilienfeld, *The Rise of Systems Theory: An Ideological Analysis* (1978). While Hoos is primarily concerned with the applications of systems analysis in public and corporate administration, Lilienfeld extends her critique to the growing body of systems thought in the social sciences. Both, however, focus on the technocratic implications of systems theory, and both see Bertalanffy as providing the theoretical foundations upon which all other applications of systems methodologies were based. Lilienfeld describes GST as "the basic science of which systems engineering, operations research, and human engineering represent applied sciences." Even more misleading is Hoos's comment that "Bertalanffy saw the system orientation as serving and hastening the process of mechanization, automation, and devaluation of man." Rather than acknowledging the possibility of a systems approach that might address the limitations of the narrower focus of systems analysis in public policy, Hoos lumps them together indiscriminately.[80]

Bertalanffy himself wrote, "I, personally, am not enthusiastic about the applications of systems in industry and politics but they are a fact." Of course, it is important to recognize that he himself contributed to the confusion regarding his relationship to the broader developments in the systems field, and Lilienfeld accurately points out that Bertalanffy's writings were often contradictory on this issue. In his efforts to portray the emergence of systems approaches as a new way of thinking about complex systems in a wide variety of fields, he often cited such developments as systems analysis and operations research as examples. And Hoos provides an excellent critique of the attempt to transplant concepts and techniques of systems design from engineering into corporate and government planning and administration, reflecting a "yearning for the same neat ordering of human affairs that is found in the management of technical matters." However, she argues that such approaches made "no allowance for humane sentiments or moral judgments," the same complaint that motivated Bertalanffy's concern with a more humanistic approach to the design of social and technological systems.[81]

Hoos and Lilienfeld both address the problem of the growing body of systems "experts," the "professional problem solvers," who promised to "manage the present scientifically and design the future rationally." Lilienfeld focuses on the ideological nature of systems theory, which, in the name of objective science, conceals the interests of its proponents in securing for themselves a privileged role in the management of society. While it may ground itself in the interests of the whole, it is really supporting the particular interests of a certain group or class. Again, disregarding Bertalanffy's own criticism of the bureaucratization and "robotization" resulting from technocratic approaches to systems management, Lilienfeld characterizes systems theory as "the benevolent control of society as a *closed* system." The significance that Bertalanffy attributed to his open-system concept was clearly lost on his critics.[82]

In his summary, Lilienfeld describes systems theory as "pretentious nonsense," rooted in classical positivism and behaviorism. Further, he argues that systems theory presumes a rigid determinacy in science. However, it is precisely the element of creativity and spontaneity that Bertalanffy saw as fundamental to the nature of organisms and societies as open systems. And it was clearly this element that motivated his violent reaction against the robot model of the behaviorist school of psychology. In his discussion of systems theory and ideology, Alvin Gouldner suggests that the technological consciousness reflects "the repression of ethics as a category of life." In its reaction against the positivistic orientation of this technological consciousness, Gouldner describes the romantic tradition as particularly opposed to the mechanistic view and its emphasis on the role of external forces over any kind of active internal nature, a position with which Bertalanffy was far more closely aligned.[83]

Hoos's and Lilienfeld's critiques of systems theory as technocratic ideology focused on the positivistic aspects of systems approaches, portraying systems theory as an attempt to apply scientific techniques and quantitative methodology in fields where they were inappropriate. In addition, there were other critiques that challenged the scientific legitimacy of systems theory in any field. Most of the latter focused on the inadequacy of analogical reasoning, and many objected to its holistic and organismic foundations. Fundamental to all of these critiques is a concern with the application of mathematical models in the biological, behavioral, and social sciences. David Berlinski offers a scathing critique of the mathematical dimensions of GST, although he admires Bertalanffy's theoretical work in elaborating such biological principles as growth and allometry. Still he argues that his overall conception is fundamentally obscure.[84]

In a symposium on GST as an approach to the unity of science, Carl Hempel argues that isomorphisms are not useful in science, and echoes a common complaint that Bertalanffy fails to make a solid case for his distinction between analogies and homologies. Although Bertalanffy claims that GST could be used as a tool to distinguish the two, Lilienfeld points out that he fails to explain how. Hoos suggests that isomorphisms are nothing more than "tired truisms about the universal applicability of mathematics." Morever, she points out that superficial analogies can be misleading, camouflaging crucial differences, leading to erroneous conclusions, and impeding analytical advances.[85]

Addressing biological applications of GST, which he sees as more valid than Bertalanffy's broader attempts at mathematical elaboration of general system principles, Hans Jonas points out that most problems of morphology and physiological process cannot be quantified using the steady-state equations that are central to Bertalanffy's model. Further, he argues that some of the system laws that Bertalanffy proposes, such as exponential and logarithmic laws, are, like the laws of addition, simply not that meaningful. Along slightly different lines, D. C. Phillips argues that Bertalanffy fails to specify clearly what is meant by a system and to explain how to determine the boundaries of any particular system without leaving out essential elements of the system. More importantly, he argues that GST fails as a scientific theory because it is incapable of predicting future events. Lilienfeld insists that systems theory has contributed nothing of substance to any field, beyond the purely technical and limited successes of operations research in narrowly specified contexts, with the exception of a new vocabulary that, he argues, "has added nothing new to our understanding of the world in any sense."[86]

CONCLUSION

These critiques emerged in the 1970s in response to the relatively uncritical embrace of systems concepts in a broad range of disciplines, and have continued to shape contemporary views of the entire body of systems thought. While they are understandable in light of the excessive expectations placed upon the "systems approach," particularly in the areas of public policy and administration, it is important to ask whether such harsh judgement is warranted, and whether or not there might be distinct strands of systems thought that merit further consideration. Perhaps it is possible to deflate some of the overinflated aspirations of systems theorists, while remaining sensitive to the potential contributions of a more integrated and holistic way of understanding complex systems. Lilienfeld argues that systems theory is largely programmatic. In that sense Bertalanffy's work might be compared with that of seventeenth-century philosopher Francis Bacon, who actually contributed very little to the development of an empirically based science, but instead provided its vision, purpose, and direction.[87]

Although Bertalanffy himself often characterizes GST as a logico-mathematical field, it is a mistake to equate his conception of systems theory exclusively with quantitative analysis, as Ida Hoos does in her discussion of his work. She offers a fairly accurate summary of his basic intent—seeking a general theory of systems, based on what he saw as a "tendency toward integration in the various sciences" that could provide the foundation for "exact theory in the nonphysical sciences," through the development of unifying principles that would apply in a variety of disciplines. However, she describes his approach to the development of such theory in terms of computerization, simulation, cybernetics, and information theory, based on the general model of a feedback system, which is simply not an accurate characterization of Bertalanffy's work.[88]

Hoos equates systems theory and cybernetics, characterizing both as reinforcing a "machine view of nature" and contributing to the "scientific management of society," tendencies that Bertalanffy himself decried in the mechanistic approach. Hoos's characterization is not even accurate in relation to further developments in cybernetics, much less in relation to the evolution of the general-systems tradition. Echoing Bertalanffy's concern with values, Gouldner argues that scientific and technological expertise can only rationalize the instrumental means used to achieve given organizational goals, but not the goals themselves, which can only be legitimated by value systems. While Lilienfeld argues that systems theory evades the problem of conflicting values, Bertalanffy continually emphasized the importance of a pluralistic approach. Further, Lilienfeld suggests that the organismic roots of systems theories led them to disregard the phenomena of uniqueness and historicity. However, it is the evolutionary nature of open systems that gives them their uniqueness in Bertalanffy's conception. In contrast to the cybernetic model, he often described his own view as evolutionary, which Lilienfeld ironically interprets as a form of social Darwinism. While Bertalanffy often emphasized the importance of the individual, he was extremely critical of the competitive individualism that he saw as characterizing the economic values of contemporary society.[89]

Bertalanffy described the aim of GST in terms of establishing principles that would apply to phenomena not yet addressed in conventional science. In responding to critiques of the use of analogy, he argued that it is a fundamental method in science, pointing to the Newtonian analogy between the behavior of apples, planets, and tides. Likening the system concept to such generalized concepts as mass, acceleration, and energy, he characterized his work as an "attempt to give a general definition of the concept of 'organized system,' to classify logically different types of systems, and to work out mathematical models for describing them." Most importantly, he constantly emphasized that his organismic systems approach was not a "nothing-but" philosophy, acknowledging that it could only present certain aspects of reality, "richer and more comprehensive," perhaps, "but never exhaustive, exclusive or final."[90]

In his comments on Bertalanffy's contributions to the development of systems thought, Jere Clark writes that there is a tendency to "assume erroneously that GST is static, impractical, mechanical, linear, closed, and 'soulless.'" He suggests, further, that people are beginning to understand the "general ecology of nature" as "dynamic, action-oriented, organismic, relative, nonlinear, open-ended, value-conscious, holistic and interdependent." Clark defines GST as the "study of patterns of relationships among the various 'species' [systems, subsystems, etc.] . . . or fields . . . of knowledge," with an emphasis on "optimizing the overall, symbiotic fruits of synergistic interaction among them." In incorporating this perspective into the educational curriculum, he hoped to "help people generally to become masters—rather than victims—of the technological forces shaping our world." Even more significantly, he thought this approach would foster "grass-roots involvement in global, participatory democracy."[91]

It is in light of such comments that Bertalanffy's contributions and the field of general systems theory should be reevaluated. Rather than a totalizing conception of reality, as so many of his critics claim, Bertalanffy's GST was an attempt to articulate a more inclusive and global perspective. In his view, the most important characteristic of open, living systems was their capacity for creativity and self-transcendence. While seeking patterns of organization that were applicable at different levels of organization, Bertalanffy still preserved a place for the individual and the particular as an essential component of social organization. Clearly some of his early work lends itself to the kinds of criticism leveled at the field in general; in his foreword to the 1961 edition of *Modern Theories of Development,* Bertalanffy apologizes for the reformatory zeal and the presumptuousness of youth that characterize his early writings. On the other hand, the excesses of his youthful enthusiasm should not diminish the value of the general orientation that his conception of general systems theory has contributed through the work of others who have drawn their inspiration from his vision.[92]

NOTES

1. Ludwig von Bertalanffy, *General System Theory: Foundations, Development, Applications* (New York: George Braziller, 1968), p. xxiii.

2. Ida Hoos, *Systems Analysis in Public Policy: A Critique* (Berkeley: University of California Press, 1972), p. 41. She cites Bertalanffy, "General Systems Theory and a New View of the Nature of Man," a paper given at American Psychiatric Association Annual Meeting, 1968, pp. 5–6.

3. Ludwig von Bertalanffy, "Mind and Body Re-Examined," *Journal of Humanistic Psychology* (1966): 136; Ervin Laszlo, "Introduction: The Origins of General Systems Theory in the Work of Von Bertalanffy," in Ervin Laszlo and William Gray, eds., *The Relevance of General Systems Theory: Papers Presented to Ludwig von Bertalanffy on His Seventieth Birthday* (New York: George Braziller, 1972), pp. 5–10; William Gray and Nicholas D. Rizzo, "Introduction" and "Correspondence of Aldous Huxley and Ludwig von Bertalanffy," in William Gray and Nicholas D. Rizzo, eds., *Unity Through Diversity: A Festschrift for Ludwig von Bertalanffy* (New York: Gordon and Breach, 1973), pp. xvi, 187; David Berlinski, *On Systems Analysis: An Essay Concerning the Limitations of Some Mathematical Methods in the Social, Political, and Biological Sciences* (Cambridge, MA: MIT Press, 1976), p. 9.

4. Quotes from Ludwig von Bertalanffy, *Problems of Life: An Evaluation of Modern Biological Thought* (New York: John Wiley and Sons, 1952), p. 202; and Robert Rosen, "Autobiographical Reminiscences," *International Journal of General Systems* 21:1 (August 1992): 19. See also Mark Davidson, *Uncommon Sense: The Life and Thought of Ludwig von Bertalanffy (1902–1972), the Father of General System Theory* (Los Angeles: J. P. Tarcher, 1983), pp. 72, 74.

5. Ludwig von Bertalanffy, "Der Organismus als physikalisches System betrachtet," *Die Naturwissenschaften* 28 (1940): 521–531; Anatol Rapoport, "Bertalanffy's Contributions to Biology," *General Systems* 17 (1972): 219–220; Ralph Gerard, letter in support of Bertalanffy's application, Dec. 5, 1953, in Ralph Waldo Gerard Collection, Department of

Special Collections, University of California at Irvine, Box 11. Quote from Bertalanffy's foreword to the 1961 edition of *Modern Theories of Development: An Introduction to Theoretical Biology* (New York: Harper, 1961), p. vii. Priority disputes refer to the work of such individuals as Alexander Bogdanov, Alfred Lotka, Alfred North Whitehead, Walter Cannon, Paul Weiss, and Ross Ashby. Donna Haraway, in *Crystals, Fabrics, and Fields: Metaphors of Organicism in Twentieth-Century Developmental Biology* (New Haven: Yale University Press, 1976), writes that J. S. Haldane referred to himself as an organicist in the 1910s, which would predate Bertalanffy's introduction of the organismic conception in 1926 (p. 38; see also Bertalanffy, *Problems of Life,* pp. 9, 181, 197).

6. Quote from Bertalanffy, *General System Theory,* p. viii; see also pp. vii, xix–xii; Davidson, *Uncommon Sense,* p. 21.

7. Davidson, *Uncommon Sense,* pp. 21–23, 25.

8. Quote from Bertalanffy, *General System Theory* (1968), p. 248; see also p. xxii; Davidson, *Uncommon Sense,* pp. 32–33; Viktor Frankl, "Beyond Pluralism and Determinism," in Gray and Rizzo, eds., *Unity Through Diversity,* p. 947; and Peter Checkland, *Systems Thinking, Systems Practice* (New York: Wiley, 1981).

9. Quote from Bertalanffy, *General System Theory,* p. 52; see also pp. xix–xxii, 23; Nicholas Rizzo, "The Significance of Von Bertalanffy for Psychology," in Laszlo and Gray, eds., *The Relevance of General Systems Theory,* p. 138. Davidson suggests that Bertalanffy damned cybernetics because it upstaged systems thought (*Uncommon Sense,* p. 204). Bertalanffy wrote that cybernetics dominated systems thinking in the United States, reinforcing mechanistic conceptions, in *General System Theory,* p. 160.

10. Ludwig von Bertalanffy, "The World of Science and the World of Value," in J.F.T. Bugenthal, ed., *Challenges of Humanistic Psychology* (New York: McGraw-Hill, 1967), pp. 335, 337 (first presented as address at Central Washington State College in 1962); Bertalanffy, *General System Theory,* p. xxii.

11. Gray and Rizzo, "Introduction," p. xiii; Kenneth Boulding, Letter to Clark Kerr, Jan. 27, 1955, in Kenneth Boulding Collection, Bentley Historical Library, University of Michigan (hereafter referred to as KEB/MI), Box 5; Letter from Boulding to Ralph Tyler, Feb. 26, 1954 (KEB/MI, Box 5); Memo to Boulding from James G. Miller, March 24, 1958 (KEB/MI, Box 7); Boulding in Davidson, *Uncommon Sense,* p. 18; Rosen, "Autobiographical Reminiscences," p. 19.

12. Bertalanffy, "The World of Science," pp. 339–340; also *Problems of Life,* pp. 20–21; Maria von Bertalanffy, "Reminiscences," in Gray and Rizzo, eds., *Unity Through Diversity,* p. 49. Mark Davidson interviewed a number of Bertalanffy's former students from the State University of New York at Buffalo, who all spoke quite highly of him (personal interview with Davidson, January 1994). Additional comments are included in Maria's article, as well as in Gray and Rizzo, "Introduction," p. xvii.

13. William Gray, "Introduction to Section I: Ludwig von Bertalanffy: Person and Work," in Gray and Rizzo, eds., *Unity Through Diversity,* p. 3; Davidson, *Uncommon Sense,* pp. 47–49; Maria von Bertalanffy, "Reminiscences," pp. 32–33. See Carl Schorske's portrayal of the nineteenth-century legacy of Bertalanffy's Vienna, in *Fin de Siècle Vienna: Politics and Culture* (New York: Vintage, 1981/1961).

14. Davidson, *Uncommon Sense,* pp. 49–54; Maria von Bertalanffy, "Reminiscences," pp. 33, 39; William Johnston, "Von Bertalanffy's Place in Austrian Thought," in Gray and Rizzo, eds., *Unity Through Diversity,* p. 25; Bertalanffy, *Fechner und das Problem der Integrationen höherer Ordnun* (dissertation).

15. Anatol Rapoport, "In Memoriam: Ludwig von Bertalanffy," *General Systems* 17 (1972): v (Rapoport points out that A. C. Burton developed the open-system concept

concurrently in Canada); Gray and Rizzo, "Introduction," p. xiii; Maria von Bertalanffy, "Reminiscences," p. 48; William Johnston, "Bertalanffy's Place," in Gray and Rizzo, eds., *Unity Through Diversity,* pp. 21, 27. According to Rapoport, Bertalanffy was only at the Menninger Foundation for one year. Maria, however, writes that this appointment lasted until 1961.

16. Ludwig von Bertalanffy, "Zur Theorie der organische Gestalt," *Roux' Archiv* 108 (1926); Ludwig von Bertalanffy, *Kritische Theorie der Formbildung* (Berlin: Gebrüder Borntraeger, 1928), see especially "Life as a System-Property," pp. 47–50, and "The System Theory," pp. 177–187, in 1961 edition of *Modern Theories of Development* (New York: Harper; originally published by Oxford University Press, 1933); William Gray, "Introduction to Section I," p. 3; Rapoport, "Bertalanffy's Contributions," p. 219. Maria von Bertalanffy writes that Julius Schaxel, who was editor of a series on theoretical biology, asked Bertalanffy to write *Kritische Theorie* after having read some of his earlier papers ("Reminiscences," p. 36).

17. Bertalanffy, *Modern Theories;* and *Theoretische Biologie* (Berlin: Gebrüder Borntraeger, 1932); D. M. Ross, "Ludwig von Bertalanffy: Leading Theoretical Biologist of the Twentieth Century," in Gray and Rizzo, eds., *Unity Through Diversity,* pp. 62–63; Rapoport, "Bertalanffy's Contributions," pp. 219–220; Joseph Needham, "Review of *Theoretische Biologie,*" *Nature* 132 (1933): 986; E. S. Russell, "Review of *Theoretische Biologie,*" *Science Progress* (1933).

18. Maria von Bertalanffy, "Reminiscences," pp. 32, 40–44 (quote from p. 44); Cynthia Kerman, *Creative Tension: The Life and Thought of Kenneth Boulding* (Ann Arbor: University of Michigan Press, 1974), p. 46; Gray, "Introduction to Section I," p. 4; Davidson, *Uncommon Sense,* pp. 54–58. Bertalanffy had published a book, *Lebenswissenschaft und Bildung* (Erfurt: Kurt Stenger, 1930), that denounced biological justifications of racism and was subsequently destroyed by the Nazis. In addition, he had published a number of popular science articles in *Der Kurier,* a Soviet-backed paper.

19. Maria von Bertalanffy, "Reminiscences," pp. 32, 39–40, 45–46; Davidson, *Uncommon Sense,* pp. 46, 56–60; Rapoport, "Bertalanffy's Contributions," p. 220.

20. Maria von Bertalanffy, "Reminiscences," pp. 46–48; Davidson, *Uncommon Sense,* pp. 46, 59, 64; letter from Bertalanffy to Kenneth Boulding (Jan. 24, 1954) in KEB/MI, Box 5; Ludwig von Bertalanffy, "Philosophy of Science in Scientific Education," *Scientific Monthly* 77 (1953): 233–239. This last article also prompted responses from the Foundation for Integrated Education and Bell Telephone, both of whom wanted to use his ideas in their educational programs, as well as from Roy Grinker at the University of Chicago, who invited him to join his group working on a unified theory of human behavior (see letter from Bertalanffy to Aldous Huxley, Jan. 13, 1954, "Correspondence," in Gray and Rizzo, eds., *Unity Through Diversity,* p. 201). Maria writes that Bertalanffy was terminated at Mt. Sinai as a result of financial difficulties, while James Miller (in a personal interview, July 1995), who arranged the position for Bertalanffy, said that he was more interested in cancer research than in psychosomatic medicine.

21. Bertalanffy, *Problems of Life,* pp. 189–193, 196–197; Wolfgang Köhler, *Die physischen Gestalten in Ruhe und im stationären Zustand* (Erlangen: Philosophische Akademie, 1924). Köhler's work was actually anticipated in 1890 by Christian von Ehrenfels, who defined *gestalten* as psychical states or events that could not be understood simply by adding up their components. Bertalanffy also acknowledges the influence of Whitehead and Smuts (although he is critical of the latter's conception of holism), Claude Bernard (whose work he was not familiar with until later), and Hegel, in his conception of nature as an organic whole, which is dynamic, discontinuous, and antithetical. See Sabine Brauckmann, "The

Organismic System Theory of Ludwig von Bertalanffy (1926–1937)," *Biologisches Zentralblatt* 115 (1996): 197–205.

22. Bertalanffy, *Modern Theories,* pp. 28–46, and "Mechanism and Vitalism in the Light of Critical Biology," *Psyche* 10 (1930): 60–72. See Chapter 3 for a discussion of Driesch's work.

23. Quote from Bertalanffy, *Problems of Life,* p. 57; see also pp. 55–60, 65–67 (especially his discussion of Hans Spemann's work on the organizer concept and Richard Goldschmidt's work on chemical factors in development as examples of organismic perspectives).

24. Quotes from Bertalanffy, *Modern Theories,* p. 65; see also pp. 48, 64, 177–178, 188; "Mechanism and Vitalism," pp. 69–71; *Problems of Life,* pp. 169–171.

25. Quote from Bertalanffy, *Problems of Life,* p. 20; see also pp. 9, 19–20, 165; Arthur Eddington, *The Nature of Physics* (Ann Arbor: University of Michigan Press, 1958), p. 103; cited in Ludwig von Bertalanffy, "Chance or Law," in A. Koestler and J. R. Smythies, eds., *Beyond Reductionism: New Perspectives in the Life Sciences* (New York: Macmillan, 1969), emphases in original.

26. Quote from Bertalanffy, *Problems of Life,* p. 11; see also pp. ix, 11–12, 147–148, 157, 167, 177–181. Bertalanffy cautioned against the tendency to equate physical indeterminacy with free will, since these concepts reflect different levels of organization.

27. Bertalanffy, *Problems of Life,* pp. 20–27, 31, 37, 65, 151, 172; J. H. Woodger, "The 'Concept of Organism' and the Relation Between Embryology and Genetics," *Quarterly Review of Biology* 5/6 (1930–1931); and J. H. Woodger, *The Axiomatic Method in Biology* (Cambridge: Cambridge University Press, 1937).

28. Bertalanffy, *Problems of Life,* pp. 44–47, and "Mechanism and Vitalism," p. 71. While some biologists accept the idea of laws unique to biology as a matter of course, others consider it a vitalist stance (see *Problems of Life,* p. 151).

29. Bertalanffy, *Problems of Life,* pp. 51–53; Bertalanffy, *General System Theory,* p. 102; Davidson, *Uncommon Sense,* p. 87. Bertalanffy's organismic conception inspired German forestry via H. Lemmel's *dauerwald* (permanent forest) idea, which encouraged the preservation of natural biocoenosis as far as possible ("Die Organismusidee," in Alfred Möllers, *Dauerwaldgedanken* [Berlin: J. Springer, 1939]). See *Problems of Life,* p. 184, for further discussion of ecological applications of the organismic conception.

30. Quote from Bertalanffy, *Problems of Life,* p. 54; also pp. 64, 93, 109, 112; *Modern Theories,* p. 173; *General System Theory,* p. 101; *Kritische Theorie,* p. 64; "Chance or Law," pp. 64–74; *Robots, Men, and Minds: Psychology in the Modern World* (New York: George Braziller, 1967), p. 87. Bertalanffy credits R. Woltereck with the term "anamorphosis."

31. Quotes from Bertalanffy, *Problems of Life,* pp. 15, 107, 112; also pp. 92–93, 103–105; and William Gray and Nicholas D. Rizzo, "Introduction to Section II: General and Open Systems," in Gray and Rizzo, eds., *Unity Through Diversity,* p. 241.

32. Quote from Bertalanffy, "Mechanism and Vitalism," p. 71; also "Chance or Law," pp. 69–70, 75; *Robots, Men, and Minds,* pp. 83, 86; *Problems of Life,* pp. 74–75, 106.

33. Quote from Bertalanffy, *Modern Theories,* p. 190, also p. v; *Problems of Life,* p. 21; E. Zerbst, "The Impact of Von Bertalanffy on Physiology," in Laszlo and Gray, eds., *The Relevance of General Systems Theory,* p. 72.

34. Joseph Needham, "Thoughts on the Problem of Biological Organization," *Scientia* 26 (1932), cited in Bertalanffy, *Problems of Life,* p. 128; Rapoport, "Bertalanffy's Contributions," p. 219; Zerbst, "Impact of Von Bertalanffy," p. 69; Bertalanffy, *General System Theory,* p. 12; Barry Commoner, "In Defense of Biology," *Science* 133 (1961): 1745–1748; T. Dobzhansky, "Are Naturalists Old-Fashioned?" *American Naturalist* 100 (1966): 541–550; R. Dubos, "We Are Slaves to Fashion in Research," *Scientific Research* (Jan. 1967): 36–54.

35. Bertalanffy, *Problems of Life,* pp. 18–19, 180. Letter from Aldous Huxley to Julian Huxley (Feb. 15, 1953), "Correspondence," in Gray and Rizzo, eds., *Unity Through Diversity,* pp. 199–200.

36. Ludwuig von Bertalanffy, "Problems of Organic Growth," *Nature* 163 (Jan. 29, 1949): 156–158 (especially table of metabolic types, p. 157); *Problems of Life,* p. 138; *General System Theory,* pp. 163–164; Ross, "Ludwig von Bertalanffy," pp. 59, 61. See also Bertalanffy, "Quantitative Laws in Metabolism and Growth," *Quarterly Review of Biology* 32 (1957): 217–231; Julian Huxley, *Problems of Relative Growth* (London: Methune and Co., 1932); A. E. Needham, "The Mathematical Definition of Growth," in Gray and Rizzo, eds., *Unity Through Diversity,* pp. 591–622.

37. Bertalanffy, *General System Theory,* p. 123, 147, 158; "Problems of Organic Growth," pp. 156–157; *Problems of Life,* pp. 136–137. Bertalanffy's growth equations were adopted by the Food and Agriculture Organization of the United Nations, as well as other governmental organizations (*General System Theory,* p. 104).

38. Bertalanffy, *Problems of Life,* pp. 123–127, 133–139 (quote on p. 124); *Robots, Men, and Minds,* p. 73; *General System Theory,* pp. 121–125 (this chapter is a translation of his original 1940 article on open systems); Zerbst, "Impact of Von Bertalanffy," p. 70. Bertalanffy introduced the German term *Fliessgleichgewicht,* or "flow equilibirium," to describe the dynamic steady state. He points out that organisms had previously been understood as systems in dynamic equilibrium, but there had been no formal definition nor working out of principles governing such a state. His work on open systems, published in 1940, emerged a year after Burton published a similar formulation in Canada (see *Problems of Life,* pp. 125–127).

39. Bertalanffy, *Problems of Life,* pp. 125–127; *Robots, Men, and Minds,* pp. 74–78; *General System Theory,* p. 39; "General System Theory," *General Systems* 1 (1956): 3–4. See also Bertalanffy, "Open Systems in Physics and Biology," *Nature* 163 (Jan. 29, 1949): 384; Ilya Prigogine and J. M. Wiame, "Biologie et thermodynamique des phénomènes irréversibles," *Experientia* 2 (1946); and Ilya Prigogine, *Étude thermodynamique des phénomènes irréversibles* (Paris: Dunot, 1947). See Bertalanffy, "General System Theory: A Critical Review," *General Systems* 7 (1962): 10–12, and *General System Theory,* p. 100, on biological applications of information and game theory.

40. Quotes from Bertalanffy, "Theoretical Models in Biology and Psychology," *Journal of Personality* 20 (1951): 37; and *Problems of Life,* p. 134, also pp. 128–129, 132, 141–143; *Robots, Men, and Minds,* pp. 73–77; *General System Theory,* pp. 132, 136, 141.

41. Bertalanffy, "General System Theory," p. 5; *General System Theory,* p. 22; "Theoretical Models," p. 34; J. Kamaryt, "From Science to Metascience and Philosophy," and A. Koestler, "The Tree and the Candle," in Gray and Rizzo, eds., *Unity Through Diversity,* pp. 80, 287; Davidson, *Uncommon Sense,* p. 80; Daniel Katz and Robert Kahn, *The Social Psychology of Organizations* (New York: Wiley, 1966); Richard W. Scott, *Organizations: Rational, Natural, and Open Systems* (Englewood Cliffs, NJ: Prentice-Hall, 1981). See Bertalanffy, "General System Theory: A Critical Review," pp. 10–12, for a discussion of additional applications and further development of the open-system idea.

42. Quotes from Bertalanffy, *Problems of Life,* pp. 125, 199; and Russell Ackoff, "Games, Decisions, and Organizations," *General Systems* 4 (1959): 145–150. Ackoff is cited in "General System Theory: Critical Review," p. 1, see also p. 9; Bertalanffy, "General System Theory," p. 2; D. C. Philips, *Holistic Thought in Social Science* (Stanford, CA: Stanford University Press, 1976), p. 64. Gregory Bateson wrote that the systems movement was "one of the most significant historical events." (See Davidson, *Uncommon Sense,* p. 191).

43. Quotes from Bertalanffy, *Robots, Men, and Minds,* p. 55; "General System Theory: Critical Review," p. 8. See also *Robots, Men, and Minds,* p. 70; *Problems of Life,* p. 202; *General System Theory* (1968), pp. 14, 37; Laszlo and Gray, eds., *The Relevance of General Systems Theory,* p. 186. Bertalanffy argued that GST fit the Kuhnian model of scientific revolutions (Davidson, *Uncommon Sense,* p. 189).

44. Quote from Bertalanffy, "General System Theory: Critical Review," p. 1; also "Chance or Law," p. 56; *Robots, Men, and Minds,* p. 58; *General System Theory,* p. 16; Phillips, *Holistic Thought,* p. 50. Bertalanffy credits fellow Austrian Julius Wagner von Jauregg, winner of the 1927 Nobel Prize in physiology and medicine, with the introduction of the feedback concept. See Chapter 2 for a discussion the Alpbach Group, which included members of the Theoretical Biology Group in England.

45. Bertalanffy, "General System Theory: Critical Review," pp. 2, 4, 6, 9 (quote p. 18); "Chance or Law," pp. 57–59; *Problems of Life,* p. 204; *General System Theory,* pp. 49, 183.

46. Bertalanffy, "General System Theory: Critical Review," p. 10; Carl Hempel, "General System Theory and the Unity of Science," *Human Biology* 23 (1951): 316.

47. Bertalanffy, "Theoretical Models," pp. 26, 34–36; *General System Theory,* pp. 23, 88, 178; "General System Theory," p. 1; "General System Theory: Critical Review," pp. 10–11; Davidson, *Uncommon Sense,* pp. 171–172. Bertalanffy points out that Mendel's original work in genetics was based on a formal model, and that formal constructs can be useful in early stages of scientific development.

48. Bertalanffy, "General System Theory," pp. 7, 9; "General System Theory: Critical Review," p. 4; *General System Theory,* p. 50; *Robots, Men, and Minds,* pp. 65, 69.

49. Bertalanffy, *Robots, Men, and Minds,* pp. 59–64.

50. Bertalanffy, "General System Theory," p. 8; Davidson, *Uncommon Sense,* p. 195.

51. Bertalanffy, "General System Theory," p. 6; *General System Theory,* pp. 16, 23, 44, 140, 163; *Robots, Men, and Minds,* pp. 65–69. Gregory Bateson, *Steps to an Ecology of Mind* (San Francisco: Chandler, 1972).

52. Bertalanffy, "General System Theory: Critical Review," pp. 6–10 (quote p. 8); *General System Theory,* pp. 98, 149–150, 161; *Robots, Men, and Minds,* p. 67.

53. Bertalanffy, "General System Theory," pp. 5–7; *General System Theory,* pp. 22–23, 43, 97–98, 150–152; "General System Theory: Critical Review," p. 5. Bertalanffy notes that Walter Cannon, whose work was so influential in the development of cybernetics, acknowledged the importance of heterostasis. Much has been written on the problem of equating information and negative entropy. See, for example, Lee Thayer, "Communication Systems," in Gray and Rizzo, eds., *Unity Through Diversity,* p. 121.

54. Bertalanffy, *General System Theory,* pp. 37, 90; *Problems of Life,* pp. 159, 199; "General System Theory," p. 7; "Chance or Law," pp. 60–63; *Robots, Men, and Minds,* p. 71; Davidson, *Uncommon Sense,* p. 175. While Bertalanffy writes that hierarchical order eludes mathematical theory, he had earlier mentioned Joseph Needham's work defining hierarchical relationships in mathematical terms.

55. Bertalanffy, "Chance or Law," p. 61; *Problems of Life,* p. 111; *General System Theory,* p. 56; Davidson, *Uncommon Sense,* pp. 196–197; Robert Rosen, "Some Systems Theoretical Problems in Biology," in Laszlo and Gray, eds., *The Relevance of General Systems Theory,* pp. 49–50. See George Richardson's discussion of the use of differential equations in the evolution of feedback thought (*Feedback Thought in Social Science and Systems Theory* [Philadelphia: University of Pennsylvania Press, 1991]); also Donella Meadows, Dennis Meadows, J. Randers, and W. W. Behrens, *The Limits to Growth* (New York: University Books, 1972). Bertalanffy writes that "the central point of system theory is the dynamic view, not the triviality that differential equations can be used to describe various

phenomena," in "General System Theory: A New Approach to the Unity of Science/ Conclusion," *Human Biology* 23 (1951): 343–344.

56. Bertalanffy, *Robots, Men, and Minds,* p. 71; "Theoretical Models," pp. 24–25; "General System Theory: Critical Review," p. 16; *General System Theory,* p. 113; *Problems of Life,* p. 162; Rosen, "Some Systems Theoretical Problems," pp. 47–48.

57. Bertalanffy, "General System Theory: Critical Review," p. 16; *General System Theory,* p. 24; *Problems of Life,* pp. 83, 152–154, 158–161; "General System Theory: A New Approach," pp. 303, 337. Bertalanffy also refers to the work of D'Arcy Thompson in *On Growth and Form* (Cambridge: Cambridge University Press, 1942) that influenced the thinking of the Theoretical Biology Group in England, as well as Kenneth Boulding's work in economics.

58. Robert Rosen, "A Survey of Dynamical Descriptions of System Activity," in Gray and Rizzo, eds., *Unity Through Diversity,* pp. 461–463. See Bertalanffy (*Problems of Life,* p. 159) for a discussion of nonquantitative mathematics; also Anatol Rapoport ("Mathematical General System Theory," in *Unity Through Diversity,* pp. 437–460) and W. Beier and R. Laue ("On the Mathematical Formulation of Open Systems and Their Steady States," in *Unity Through Diversity,* pp. 479–494) for further discussion of the mathematical dimension of GST.

59. Bertalanffy, *General System Theory,* pp. 22, 32, 81–84, 102; "General System Theory," pp. 2, 7; *Problems of Life,* p. 199. Bertalanffy cites discussions by Ross Ashby, Russell Ackoff, and Robert Oppenheimer regarding the use of analogy in science, a method that he argues is fundamental, but for which he was roundly criticized (see "General System Theory: Critical Review," p. 9; also Berlinski, *On Systems Analysis*).

60. Bertalanffy, *General System Theory,* pp. 33, 47–48, 64–65, 82, 102; "General System Theory," pp. 2, 7–8; "General System Theory: Critical Review," p. 9; *Problems of Life,* pp. 122, 201; *Robots, Men, and Minds,* pp. 72–73, 105; Davidson, *Uncommon Sense,* p. 176.

61. Bertalanffy, *General System Theory,* pp. 105, 208.

62. Bertalanffy, "General System Theory," p. 10.

63. Ludwig von Bertalanffy, "System, Symbol, and the Image of Man," in Iago Galdston, ed., *The Interface Between Psychiatry and Anthropology* (New York: Brunner/Mazel, 1971), pp. 89–90.

64. Nicholas Rizzo, "Significance of Von Bertalanffy for Psychology," in Laszlo and Gray, eds., *The Relevance of General Systems Theory,* pp. 138–141, 144; also Rizzo, "Introduction to Section IV: General System Theory in the Behavioral Sciences: Toward a New Image of Man," in Gray and Rizzo, eds., *Unity Through Diversity,* p. 807.

65. William Gray, "Bertalanffian Principles as a Basis for Psychiatry," in Laszlo and Gray, eds., *The Relevance of General Systems Theory,* pp. 126, 128, 132; Victor Frankl, "Beyond Pluralism and Determinism," in Gray and Rizzo, eds., *Unity Through Diversity,* pp. 948–949.

66. Rizzo, "Introduction to Section IV," pp. 811–813; Davidson, *Uncommon Sense,* pp. 130, 186. Karl Menninger is quoted in William Gray, Leonard Duhl, and Nicholas Rizzo, *General System Theory and Psychiatry* (Boston: Little, Brown, 1969), p. 447. See also Karl Menninger, *The Vital Balance: The Life Process in Mental Health and Illness* (New York: Viking Press, 1963); and Kenneth Boulding, "General Systems as an Integrating Force in the Social Sciences," in Gray and Rizzo, eds., *Unity Through Diversity,* p. 951.

67. Bertalanffy, *Robots, Men, and Minds,* pp. 7, 89, 127–129; *General System Theory,* pp. 107, 191; "Theoretical Models," p. 33; "General System Theory: Critical Review," p. 14.

68. Bertalanffy, *Robots, Men, and Minds,* pp. 9, 89–90; "General System Theory: Critical Review," p. 14; *General System Theory,* p. 190; "General System Theory and Psychiatry,"

in Silvano Arieti, *American Handbook of Psychiatry,* vol. 3 (New York: Basic Books, 1965), p. 705; "System, Symbol," p. 99; Gray, "Bertalanffian Principles," pp. 129–130.

69. Quote from Bertalanffy, "General System Theory and Psychiatry," p. 706, also p. 711; Bertalanffy, *Robots, Men, and Minds,* pp. 8–16 (Koestler quote on p. 15); *General System Theory,* pp. 189, 206.

70. Bertalanffy, *Robots, Men, and Minds,* pp. 12, 16–17; *General System Theory,* pp. 191, 207, 211; "General System Theory and Psychiatry," pp. 706, 710; Davidson, *Uncommon Sense,* pp. 102, 107–109; Vance Packard, *Hidden Persuaders* (New York: D. McKay Co., 1957). Bertalanffy was also influenced by David Reisman's work on the outer-directed nature of American society. See "System, Symbol," p. 99; and David Riesman, *The Lonely Crowd: A Study of the Changing American Character* (New Haven: Yale University Press, 1950).

71. Bertalanffy, "General System Theory and Psychiatry," pp. 710, 716; *General System Theory,* pp. 192–193, 205; *Robots, Men, and Minds,* pp. 3, 18.

72. Bertalanffy, *Robots, Men, and Minds,* p. 9; "General System Theory and Psychiatry," pp. 711, 714–715; "System, Symbol," pp. 91–93, 96; *General System Theory,* pp. 197, 212, 216–219; "The World of Science," p. 338; *General System Theory,* p. 115; "General System Theory: Critical Review," p. 117.

73. Bertalanffy, *General System Theory,* pp. 78–79; *Robots, Men, and Minds,* pp. 21, 30–33, 216–217.

74. Bertalanffy, "The World of Science," pp. 335–337, 341 (quotes pp. 335, 341); *General System Theory,* p. 196; Gray, "Bertalanffian Principles," p. 127.

75. Bertalanffy, *Robots, Men, and Minds,* pp. 8, 91–93; *General System Theory,* pp. 222, 226, 232; "Mind and Body Re-Examined," pp. 118, 120–121; "The Mind-Body Problem: A New View," in Floyd Matson and Ashley Montagu, eds., *The Human Dialogue: Perspectives on Communication* (New York: The Free Press, 1967), pp. 234, 237.

76. Bertalanffy, *Robots, Men, and Minds,* pp. 93–96; "Mind and Body Re-Examined," pp. 121–122.

77. Bertalanffy, *Robots, Men, and Minds,* pp. 32–33; "General System Theory and Psychiatry," pp. 712–713; "Mind and Body Re-Examined," p. 123; "The Mind-Body Problem," p. 231; Davidson, *Uncommon Sense,* pp. 118–119, 123–124.

78. Bertalanffy, *Robots, Men, and Minds,* p. 50; "System, Symbol," pp. 112, 117.

79. Quotes from Bertalanffy, *Robots, Men, and Minds,* p. 114, also pp. 94–95; "Mind and Body Re-Examined," p. 131; Davidson, *Uncommon Sense,* p. 151.

80. Ida Hoos, *Systems Analysis,* p. 41; Robert Lilienfeld, *The Rise of Systems Theory: An Ideological Analysis* (New York: John Wiley and Sons, 1978), p. 23.

81. Bertalanffy, *Robots, Men, and Minds,* p. 105; Lilienfeld, *The Rise of Systems Theory,* p. 8; Hoos, *Systems Analysis,* pp. 2, 39.

82. Hoos, *Systems Analysis,* pp. 3, 7; Lilienfeld, *The Rise of Systems Theory,* pp. 3, 263, 268.

83. Lilienfeld, *The Rise of Systems Theory,* pp. 247–248; Alvin Gouldner, *The Dialectic of Ideology and Technology* (New York: Seabury Press, 1976), pp. 258, 263.

84. Berlinski, *On Systems Analysis,* pp. 7, 11. See also David Hull, "Systemic Dynamic Social Theory," *The Sociological Quarterly* 11 (1970): 351–363, who writes: "According to von Bertalanffy, all systems, regardless of their subject matter, are describable by a single set of differential equations. Once this set of equations has been derived, all that remains for a scientist to do is to apply them to his own field of inquiry, whether it might be physics, biology, or one of the social sciences" (p. 351). This is a gross oversimplification of Bertalanffy's conception of general system theory.

85. Hempel, "General System Theory," pp. 315–316; Lilienfeld, *The Rise of Systems Theory,* pp. 18, 26; Hoos, *Systems Analysis,* p. 40. Hempel's paper was presented in a symposium on general system theory at the forty-seventh annual meeting of the American Philosophical Association in 1950.

86. Hans Jonas, "Comments on General System Theory," *Human Biology* 23 (1951): 330–334; Phillips, *Holistic Thought,* pp. 60–61, 64; Lilienfeld, *The Rise of Systems Theory,* pp. 172, 256.

87. Lilienfeld, *The Rise of Systems Theory,* p. 31.

88. Hoos, *Systems Analysis,* pp. 39–40.

89. Lilienfeld, *The Rise of Systems Theory,* pp. 4, 12, 31; Gouldner, *The Dialectic of Ideology,* p. 241. See Peter Taylor's comments on cybernetics in Chapter 4.

90. Bertalanffy, "General System Theory; Critical Review," pp. 9, 10.

91. Jere W. Clark, "General Ecology of Knowledge in Curriculums of the Future," in Laszlo and Gray, eds., *The Relevance of General Systems Theory,* pp. 168, 175, 177.

92. Bertalanffy, *Modern Theories of Development,* p. vi.

SEVEN The Chicago Behavioral Science Committee

> The great variety of living entities that evolution has produced are complexly structured open systems. They maintain within their boundaries their thermodynamically improbable energy states by continuous interactions with their environments. Inputs of both matter-energy and information are essential for living systems. The total inputs are lower in entropy and higher in information than the total outputs. Living systems theory is an integrated conceptual approach to the study of biological and social living systems, the technologies associated with them, and the ecological systems of which they are all parts.
>
> —James Grier Miller and Jessie L. Miller, *Living Systems*[1]

At the annual meeting of the American Psychological Association (APA) in 1953, members of the University of Chicago Committee on the Behavioral Sciences presented a symposium on the use of homeostatic models in the study of behavior. In his introduction, James G. Miller explained that the group had coined the term "behavioral sciences" in 1949 to refer to "all the overlapping biological and social disciplines concerned with the study of behavior, human or subhuman," and that they had been meeting regularly during the previous year "to work toward the development of integrated theory." While they agreed unanimously on the use of formal models in such an endeavor, there were considerable divergences in their respective approaches, reflected in Miller's opening comment, which might apply equally to the evolution of general-systems thought: "Throughout our papers you may expect to hear between our lines Pogo the Possum's cry of academic freedom, which has served for a year to unite us in brotherly schism: 'I disagree with every word you say, and will fight to your death for my right to deny it.'"[2]

Miller's Committee on the Behavioral Sciences was a product of the tremendously innovative intellectual environment fostered by Robert Maynard Hutchins, president and chancellor of the University of Chicago from 1929 to 1951. During this period a number of interdisciplinary efforts were initiated, several of which had a direct impact on the evolution of general-systems thinking through the participation of the founding members of the SGSR. Most notably, these included Nicholas

Rashevsky's Committee on Mathematical Biology, Roy Grinker's Committee on Human Behavior, and of course Miller's Committee on the Behavioral Sciences. In addition, much of the inspiration for the Center for Advanced Study in the Behavioral Sciences (CASBS) derived from the interdisciplinary approach to the study of human behavior that had been nurtured in the Chicago environment.

All of the founding members of the SGSR had been at the University of Chicago during some phase of their academic career. Kenneth Boulding spent two years there between 1932 and 1934 on a Commonwealth fellowship, during which time he began to develop his ecological perspectives on economics. Ludwig von Bertalanffy was at Chicago during the 1937–1938 academic year on a Rockefeller fellowship on the recommendation of Rashevsky, and presented his ideas about general systems theory to Charles Morris's philosophy seminar. Bertalanffy's ideas were influential in the evolution of all three of the groups mentioned above. Rashevsky was particularly interested in the development of generalized mathematical models along the lines that Bertalanffy envisioned. Roy Grinker, chair of the Division of Psychiatry at Michael Reese Hospital, hosted a biannual conference on general systems theory and invited Bertalanffy to attend while he was living in Canada in the early 1950s.[3]

Bertalanffy's presentation contributed significantly to the inspiration for Miller's committee, which began meeting in 1952 to explore the potential for an empirically testable theory of behavior. This "theory group" included representatives from history, anthropology, economics, political science, sociology, psychology, medicine, physiology, and mathematical biology. Ralph Gerard, a neurophysiologist, and Anatol Rapoport, a mathematical biologist working closely with Rashevsky, were among the members of this group, and continued to discuss related topics during their year together at CASBS in 1954–1955. The following year, Miller, Gerard, and Rapoport moved to the University of Michigan, where Boulding was already in residence as professor of economics, and continued their collaborative work at the Mental Health Research Institute (MHRI), with Miller as director. Boulding described MHRI as one of the first centers of general-systems research.[4]

This chapter addresses the work of Gerard, Rapoport, and Miller together because the roots of their collective contributions to systems theory grew out of their collaborative efforts in the behavioral-science committee and MHRI. While a number of individuals came and went over the years, these three remained a consistent core, working very closely together for at least fifteen years, from 1952 until 1967. All three shared an interest in integrating concepts and principles from the biological and social sciences, as well as a concern with the communication barriers created by the progressive specialization of scientific disciplines. Along these lines, they were also interested in the integrative role of information in biological, psychological, and social systems.

This group was more directly connected with the development of cybernetics and information theory than were either Bertalanffy or Boulding. Gerard, as a neurophysiologist whose research focused specifically on the transmission of messages in systems at all levels of organization, had been a participant in the Macy conferences on cybernetics, and he was actively involved in fostering the use of computers in education. In connection with his work with the Committee on Mathematical Biology, Rapoport was particularly interested in generalizing the work of Warren McCulloch and Walter Pitts on neural networks to other kinds of communication systems. Miller's work on information overload inspired a study group that met in 1966 and was instrumental in initiating the first university computer network.

The orientations of these three individuals were remarkably diverse, given their long and consistent association. Gerard and Miller were closer in spirit, both intellectually and politically. All three worked in some capacity with the military during World War II, although Rapoport remained a socialist throughout his career. Gerard and Miller both held fairly high-level positions in government agencies during the postwar period. Rapoport, on the other hand, was extremely critical of Cold War policies, and much of his research on game theory was directed toward a critique of the military think tanks. During the Vietnam era, Rapoport became increasingly disenchanted with the United States, eventually moving to Canada in 1970. Intellectually, he was closer to both Bertalanffy and Boulding in his emphasis on the irreducibility of the symbolic and normative dimensions of human experience, perhaps the most critical issue dividing the technocratic and humanistic approaches to GST.[5]

RALPH GERARD (1900–1974)
Neurophysiology and the Organismic Conception of Society

Along with Bertalanffy, Ralph Gerard was one of the elders among the founders of SGSR, although their conceptions of GST were quite distinct. Gerard first met Bertalanffy in 1937 during his fellowship in Chicago and wrote a letter in support of his application for a Guggenheim fellowship in 1953. Gregg Mitman describes Gerard as "a visible figure in the science and society movement in the late 1930s and early 1940s," which emphasized the role of scientists as "leaders and experts in the management and control of human society," highlighting Gerard's closer alignment with the technocratic approach to systems engineering and management that was the focus of Robert Lilienfeld's critique.[6]

Gerard enrolled at the University of Chicago in 1915 at the precocious age of fourteen. By the time he met with the others at CASBS, he had made significant contributions in the field of neurophysiology. Of the original founders, he was the least engaged in the long-term evolution of SGSR, although he remained actively involved with both Miller and Rapoport at the MHRI until he moved to the University of California at Irvine in 1963. He was closely associated with the development of the "Chicago School" of ecology in the 1930s and 1940s, particularly in connection with his conception of society as a kind of "epiorganism" or "superorg." As a neurophysiologist interested in the transmission of messages in organized systems at both the organismic and societal levels, he was invited to participate in the Macy conferences on cybernetics. Gerard's interest in the transmission of messages also stimulated his increasing concern with the role of computers in education in his later years.[7]

Early in his academic career, Gerard was introduced to the work of Conrad Sherrington on nervous-system integration, and his thinking was profoundly shaped by the Claude Bernard school of organismic biology, which had a direct impact on the evolution of cybernetics through the work of Walter Cannon and Lawrence Henderson. He also worked closely with Paul Weiss, a former engineer and member of the Biology Department at Chicago, whose work inspired both Bertalanffy's and Gerard's conception of systems. Gerard was very much influenced in his youth by Herbert Spencer's organismic conception of society, which was reflected in the organismic orientation of the University of Chicago ecologists during the early twentieth century. In an interesting contrast to the holistic orientation of his social thought, however, his understanding of neurological function was basically reductionist, as illustrated in his famous remark that there is "no twisted thought without a twisted molecule."[8]

Rapoport describes Gerard's work as "systematically fitting the biological and social sciences into a single scheme with the view of developing methodologies applicable to both." In a statement describing his proposed areas of research at CASBS, he wrote that he was interested in facilitating greater communication between the fields of physiology, psychology, psychiatry, and sociology. As a neurophysiologist involved with the early development of psychoanalysis, he sought to make the concepts of psychology accessible to both biological and social scientists, and to contribute to a "mutually acceptable formulation of principles and methods." In his discussion of Gerard's contributions in the field of neurophysiology, Ben Libet writes that he was a "prime fashioner and living example of the 'integrative and interdisciplinary' approach that has now become fashionable in neural science." He published nine books and more than 700 articles and was on the editorial boards of sixteen journals, including the *Journal of Neurophysiology,* the *Physiological Review,* and the *American Journal of Physiology*.[9]

In addition to his scientific work in neurophysiology and the behavioral sciences, Gerard was very much concerned with broader issues relating to the role of science in society, including the ethical implications of emerging ideas in science, the relationship between science and religion, and the implications of biology for understanding the evolution of language, culture, and education. He was also concerned with the impact of science on public policy and on society in general, convinced that major social problems could not be solved without the aid of science. Beginning in the 1930s, he was actively involved with a number of government agencies: chairing panels for the National Science Foundation, the National Institutes for Mental Health, and the Office for Naval Research; consulting with the chief of naval research and the surgeon general; and serving on the Executive Committee, Stress Sub-Committee, and Biology Council of the National Research Council. In addition, he was elected to the National Academy of Science and the American Academy of Arts and Sciences.[10]

Gerard was a meticulous scholar and remarkably skilled at synthesis. He was often asked to give closing remarks at conferences; he had a talent for accurately and concisely summarizing the key ideas from each of the presentations and fitting them together into a coherent picture. He was tremendously energetic and dynamic. Rapoport describes him as "spontaneous, ebullient, and warm." Libet mentions his lively wit and sense of humor. Miller writes that he often got standing ovations for his lectures and that he had "an amazing facility for relating biological ideas relevantly to almost any specific problem." In his memorial comments, Daniel Aldrich described him as an "unrelenting champion of academic excellence," "a tough, tenacious foe of the shoddy, the cheap and the untidy," and an "elitist." In drafts of an autobiography entitled "Top Level War Plans," Gerard himself writes, "I'm sure I was an intellectual snob and a prig—I have never suffered fools gladly and I'm afraid fools know it and there are so many of them it has not helped my position in the world." Of the original founders, his orientation toward the behavioral sciences was the most manipulative. He had a very paternalistic attitude about the role of science in society. In one of his essays he wrote: "If it is at all ethical to manipulate the universe, it is ethical to learn how and actually to manipulate its human components."[11]

A Life of Ambition, Genius, and Passion

Ralph Waldo Gerard was born on October 7, 1900, in Harvey, Illinois, to Maurice Gerard and Eva Teitelbaum Gerard. He describes his father as a frustrated intellectual who worked as an itinerate efficiency engineer and projected all of his ambitions onto his only son. Gerard writes of long walks with his father in his youth that inevitably became impromptu science lectures, characterizing his father as "a master teacher, a demanding prod, and a tyrant." Because they moved often, mostly between Chicago and New York, Gerard was often in the position of being the new kid and the scapegoat in the neighborhood, aggravated by the fact that he was small for his age and of Jewish descent.[12]

It is to this background that he attributes his shyness and insecurity. His mother died when he was twelve years old and for a while he stayed with a family he describes as "rather lower middle class." Later, he attended high school at Evanston Academy, a prep school associated with Northwestern Academy. There he developed a talent for verbal fencing with his best friend, which did not tend to win him friends, although he says it was mainly meant in fun. He describes himself as an ascetic, "dedicated to things of the mind." He writes, with some regret, that he didn't really like working with his hands, which accounts for his eventual move away from the laboratory toward more theoretical and synthetic kinds of work.[13]

Gerard entered the University of Chicago at the age of fourteen, completing his Ph.D. by the age of twenty-one and his M.D. at twenty-four. He was a passionate scholar, recounting that he was so excited on returning to the Chicago campus for his sophomore year that he bent down and kissed the cornerstone of the library. After listening to the story of how Emil Fischer discovered the molecular structure of certain carbon compounds, he was so entranced that he walked right into a stone pillar. The breadth of his interests is reflected in the fact that he took at least one course in every science offered, as well as in many of the liberal arts. During his junior and senior years, he taught courses in military surveying, and at the end of his second year in graduate school, when he was only twenty-one, he spent a year as chair of the Department of Physiology, Biochemistry, and Pharmacology at the University of South Dakota.[14]

On his return to Chicago, Gerard married Margaret Wilson, who had just completed a Ph.D. in neuroanatomy at Northwestern University, and they studied medicine together at Rush Medical College. In the idealistic spirit of the period, they lived in Jane Addams's Hull House and taught courses in the community several evenings a week. On completing his medical training, he accepted a fellowship from the National Research Council to work with A. Hill in London and Otto Meyerhof in Berlin from 1925 to 1927. During this period he was introduced to the work of Charles Sherrington, who was at Cambridge. Margaret studied with Anna Freud in Vienna and worked as a child psychiatrist until her death in 1954.[15]

They returned to Chicago in 1927; Gerard was appointed assistant professor of physiology and remained at the university until 1954. From 1952 until 1954 he was also director of labs at the University of Illinois Neuropsychiatric Institute. In 1954 he became the world's first professor of behavioral science. In 1955, after the year at CASBS, he moved to Ann Arbor, along with Rapoport and Miller, to become the laboratory director of the MHRI. In the same year, he married Frosty (née Leona Bachrach Chalkley). They moved to California in 1963, where Gerard was involved in organizing the new University of California campus at Irvine. There he served as professor of biological sciences, director of special studies, and dean of the graduate division, until his retirement in 1970. During this period he became actively engaged in exploring the use of computers in education, continuing to work with Miller in connection with the establishment of EDUNET, an early prototype of the Internet.[16]

Neurophysiology and Information Theory

Gerard is described as "one of the most productive and distinguished neurobiologists of his time." He made significant contributions to the field in his research on such phenomena as nerve metabolism and conduction, electrical activity in the brain during sleep, the nature of brain waves, regeneration in the central nervous system, and the action of drugs and hormones on the functioning of nerve cells—despite his proclaimed distaste for manual labor. He was especially interested in understanding the biological basis of mental illness, particularly schizophrenia, challenging the dominant theory that mental disease was purely psychological and cultural in origin. From 1958 to 1964, while he was at MHRI, he received a $1.5 million federal grant to support his research on schizophrenia.[17]

At the request of Alan Gregg of the Rockefeller Foundation, Gerard spent the mid-1930s traveling extensively in Europe, investigating research on the nervous system. His book *Unresting Cells,* originally published in 1940, was used as a reference on neural function into the mid-1970s. He participated frequently on radio panels and early television programs on the brain. He often pointed out that the human nervous system had to process two different kinds of information, one from the "material world of ordinary sense perception," and the other from the "abstracted world of symbol and idea." He suggests that the sensory vehicle is only incidental in the latter, although the symbolic dimension is created by humans on the basis of their material perception. For Gerard, the main task of neurophysiology was to figure out the physical and chemical mechanisms that allowed for the transmission of messages, and to explain how sensory input was centrally integrated and subsequently translated into awareness and behavior.[18]

His interest in information processing and learning in the nervous system led directly into broader concerns with similar processes in society, which motivated his participation in the cybernetics conferences, as well as his work on developing educational applications of computers. Just as humans had learned how to "supplement [their] muscles with bulldozers, and [their] sense organs with radar," they were now learning to supplement their brains with computers. In addition, he was interested in how the role of elites and government in the social realm paralleled processes of organization and centralization in the nervous system. Like Miller, he was grounded in a physiological conception of social processes, which perhaps lent itself more easily to a technocratic orientation.[19]

At the same time, he was sincerely motivated to explore the relationship between purely quantitative approaches and more qualitative orientations toward understanding psychological processes. While he was at CASBS, he worked with Franz Alexander exploring parallels between psychoanalytic theory and emerging neurological discoveries. This work became a small piece of a much larger project that represents his major contribution to the evolution of general-systems concepts. Prior to the year at CASBS, he began systematically examining parallel structures and functions at different levels of organization, a project that was to become the primary focus of the behavioral-science group at Chicago and the foundation for Miller's "Living Systems Theory."[20]

Like Bertalanffy, although with a slightly different focus, Gerard sought to systematize biological concepts and generalize them across related disciplines, addressing similar phenomena at different levels (molecule, organelle, cell, organ, individual, small group, species, community, ecosystem, and total biota) and comparing methodologies applied to the study of each level. At each level he examined aspects of (1) structure, including static relationships among constituent parts, such as channels of communication and lines of authority; (2) function, including the way systems at each level react to inputs from the environment; and (3) evolutionary change. This project of exploring parallel phenomena at different levels of organization provided the focus of a conference sponsored by the Biology Council of the National Academy of Science in 1955, which included among its participants such notable theoretical biologists as Ernst Mayr, Paul Weiss, and Sewall Wright, in addition to Gerard and Miller.[21]

The Organismic Conception of Society

In drawing on his training in biology for insights into social problems, Gerard tended to focus more on parallel processes or "isomorphisms" between different levels of organization and less on emergent properties, such as the symbolic dimension of human experience. This is true, to some extent, of Miller's work as well, although he does address emergent properties in *Living Systems*. While Bertalanffy identified isomorphic phenomena as a key element in GST, he was as critical of the reductionism inherent in applying biological concepts to social and psychological systems as he was of the treatment of biological phenomena in purely mechanistic terms. This perspective is echoed in the work of Boulding and Rapoport as well, and the contrast between the two approaches is critical in an analysis of the social implications of systems concepts.[22]

Gerard's conception of society was grounded in an organismic model, harkening back to his early fascination with Spencer. Organismic models were popular and influential in the newly emerging fields of sociology and ecology during the 1920s and 1930s, although they became increasingly suspect after World War II, as the application of biological principles in society became increasingly associated with fascism. The organismic approach is reflected most notably in the work of Walter Cannon, who addressed the last chapter of his book *The Wisdom of the Body* (1932) to a plea for mechanisms of social control similar to those that functioned so effectively within the organism to maintain its stability and efficiency. Similar commitments informed the work of biologists at Chicago, including Gerard, who were interested in exploring parallel processes of integration in organisms, ecological communities, and social systems. This topic was the focus of a symposium in 1941 that Gregg Mitman describes as the "first public collaboration between biology and social science at Chicago."[23]

Integrating mechanisms identified as common to the various levels included specialization, control gradients, communication, and cooperation. Control gradients were described at the social level in terms of patterns of dominance and subordination, drawing from the work on animal behavior that was the primary focus of the group of ecologists with whom Gerard was associated, including Alfred Emerson, Warder Clyde Allee, and Charles Child. Gerard's conception of the "superorg" was tied to notions of group selection that were popular within this group, forming the basis for his naturalistic ethic. In this view, conflicts between the individual and the larger society are minimized in the interest of preserving the greater good of the whole. Much of Gerard's work addressed the nature of the relationship between part and whole, drawing parallels between the evolutionary trends he observed in biological organisms and those he predicted for society.[24]

Gerard frequently discussed the respective roles of competition and cooperation in evolution. Theories of group selection emphasized the evolutionary importance of cooperation, in contrast to the emphasis on competition so central to neo-Darwinian evolutionary theory. At the same time, Gerard argued that competition had beneficial effects for the species or superorg as a whole. Nevertheless, just as the cells in the body function for the benefit of the whole organism, the individual organism must also function for the good of the whole society: "Each man . . . is a complete whole, dedicated to self-survival and in basic competition with other men; but each man . . . is a component unit of a larger whole, the society, and dedicated to group survival by basic cooperation with other men in the group."[25]

In general, Gerard believed that higher levels of integration were dependent upon the subordination of the lower levels. He often described the general trend of evolution as moving toward increasing integration at higher levels corresponding with decreasing autonomy at the lower. In the 1953 symposium presented by Miller's Committee on the Behavioral Sciences to the American Psychological Association, Gerard notes that "as the org becomes more highly integrated, the influence of the whole on the units increases relative to that of the units on the whole." Although he acknowledges that the cell does not exist solely for the organism nor the individual solely for society, he argues that "greater dependence of the individual on the group is in the line of evolution." At the same time, he recognizes that determination between part and whole is always reciprocal and partial: "The duality of man is inescapable . . . extremes of individualism and collectivism, laissez-faire and absolute economic socialism are untenable."[26]

The evolutionary trend toward integration and cooperation was manifested, for Gerard, in what he saw as a gradual increase of altruism relative to selfishness in society. He describes human behavior as "a result of basic selfish drives opposed by social education, and the altruistic ones, feebler as yet but enhanced by group conditioning," predicting the eventual formation of a "single human epiorganism," in the form of a world state, as inevitable. In "achieving a greater identification of the individual with the group," Gerard saw totalitarianism as an "expression of the great movement of evolution and in harmony with the growing altruism biology indicates," describing Germany in 1940 as unsound "in all but its basically progressive totalitarianism." Noting that "intolerance to minority groups and to other nations . . . seems to be the necessary consequence of hostility sublimated to the national level," he puzzled over how "primitive human aggressions" would be handled when "all men are forced into a single state."[27]

Still, Gerard believed that a cooperative world order would ultimately have to be rooted in democratic principles, since rule by force rather than consent would result in an unstable "org." As cooperation increases relative to conflict in the course of biological evolution, "the integrating forces shift from an emphasis on mechanical control to ever greater use of communicative control, via nerve and hormone." Similarly, as altruism continued to increase relative to selfishness, social control would be "exercised relatively more by suasion as compared to force." Gerard believed that greater social control would enhance human freedom in providing greater opportunity for self-expression, and that it would most effectively be accomplished through democratic methods (including participation, group discussion, and effective leadership), as well as through the manipulation of social attitudes.[28]

Another important task in Gerard's view was the development of more rational means of assigning individuals to those functions in the social whole for which they were best fitted. He compared this task with the role of organism gradients in the process of morphogenesis, which directed the development of initially "totipotential" cells into various paths of differentiation and specialization. Reflecting his paternalistic view of the role of science in this process, he writes: "I doubt that anything would more effectively advance our epiorganisms of today than improved placement of units in gradients at their proper gradient level. This will be ever more possible as measures of individual capacities and achievements are developed and applied." At the same time, he makes the fairly radical suggestion that "present difficulties would diminish further if the great discrepancies which exist in the social rewards for functions performed at different levels were lessened."[29]

Nevertheless, the following passages from "Organism, Society, and Science" illustrate Gerard's prejudices, along with some of the fundamental problems with his approach: "The org must modify the action of its units, but restrictions are balanced by new opportunities. Our women do not feel thwarted and unsuccessful because they are not expected to compete for money and prominence." While he suggests, with qualifications, that human units are also totipotential, he continues: "This, of course, is not to say that all men are created equal, that great mirage of primitive democracy." In addition to developing better criteria for the selection of leaders, Gerard also mentioned human breeding control, "as to both kind and number," as part of this process of social morphogenesis.[30]

The Role of Science

In response to growing disillusionment with and criticism of science as a destroyer of human values, individual freedom, and moral responsibility, and a debaser of the human spirit, Gerard wrote in defense of the values of science, which for him included honesty, industry, altruism, and cooperation. His conception of a rational, scientific approach to ethics entailed public intercommunication and agreement, although it is unclear exactly who his "public" is to include. He asks whether or not science might be able to create more effective mechanisms for better integration within the epiorganism of society. He argues that scientists need to give more thought to the human consequences of their work, in their roles as "receptors" for the social organism and as "autocatalysts" for social evolution: "The scientist is not exercising, as he should, the gradient control which his role of receptor confers upon him." At the same time, he recognized the danger that "organized science might obtain more power than it can yet wisely exercise."[31]

Gerard writes that a sense of service was lacking in earlier stages of the scientific endeavor, but that it was now necessary for scientists to "accept the responsibility of discovering truth and applying it" and further to "help educate men to behave rationally." With the threat of nuclear destruction looming, it was necessary to "apply the scientific attitude and method in human affairs to a degree hitherto undreamed of." Addressing the significance of the behavioral sciences, he writes:

> Today the great frontier of science is in the behavioral science area, where man is seeking to understand his nature, his groups, and institutions and culture, and the ways of interacting together. Here also, inevitably, understanding will beget control. . . . All organisms have evolved towards greater cooperation and altruism and man is no exception. The collective living of civilization would be impossible if benevolence were not greater than malevolence. The controls that

> behavioral science will make possible should thus lead more to good than to evil.[32]

And yet, Gerard seems to be aware of the difficulties. In notes for his paper on "Higher Levels of Integration," which he presented at the 1953 APA symposium, he cites the following passage from D. H. Loomer: "Good people often desire inordinate power just because they want to save society from its own evils. They want to universalize their own values and high moral ideals because they hold them to be valid for all people at all times and under all conditions. They refuse to recognize the sociology of their own knowledge or the finiteness of their own perspectives. They illustrate what Niebuhr calls 'original sin'—denial of one's finiteness."[33] In response, he questions his own optimistic assumptions as follows:

> The world is ever more at our individual doors and cooperation is being generalized to larger and larger groups; mankind as a whole will become an integrated cooperative unit; and the ultimate future of human society, however dark it may look to the contemporary sociologist or even to the historian, appears in the eyes of the biologist, sighting down the long perspective of organic evolution, as bright with hope. . . . Am I guilty of "original sin," of making infinite the finite, in believing that biological evolution, acting at the social level through its catalyst, science, is indeed trending toward peace on earth and good will towards man?[34]

It is along these lines that Gerard's view diverges from that of Rapoport, who also believes in the possibility of progress and the enlightening and liberating potential of positivistic science, although he tends to be a little more circumspect about the role of science in directing social evolution and much more sensitive to the potential for the abuse of power inherent in such a project.

ANATOL RAPOPORT (b. 1911)
Mathematical Biology, Game Theory, and the Prisoner's Dilemma

Anatol Rapoport's contributions to the evolution of GST involved the application of mathematics in biology and the social sciences, growing out of his work with Rashevsky's Committee on Mathematical Biology, which he joined in 1947. In fact, it was Rapoport who offered the refresher course in mathematics at the CASBS that was widely attended by the fellows in residence during the first year. Along with Gerard and Miller, he was a core member of the Committee on the Behavioral Sciences and of the research group at the MHRI, where he was coordinator of the systems sciences. Unlike Gerard and Miller, however, he was a pacifist and a socialist. While he joined the service during World War II, he worked closely with Kenneth Boulding on the development of the Center for Peace Studies and Conflict Resolution, which was established at the University of Michigan in 1956, and he left the United States in 1970 because of his opposition to the Vietnam War. His autobiography begins with an affirmation of his belief that "all forms of violence should be eliminated from human affairs."[35]

Rapoport was introduced to Gerard's work in 1938, when he gave a guest lecture in an introductory biological-sciences course that Rapoport was taking at the University of Chicago. He writes that Gerard's lecture first made him aware of the possibility of applying mathematics in the study of biology. When he returned to Chicago after the war, he took further courses from Gerard. Before joining the Committee for the Behavioral Sciences in 1952, when it began meeting on a regular basis, Rapoport had also been involved in Roy Grinker's Committee on the Study of Human Behavior. His most significant work was in the application of neural networks to phenomena such as the spread of rumors or of disease in large populations, the mathematical analysis of language, and the development of non–zero-sum models in game theory. He is probably best known for his winning strategy in the "Prisoner's Dilemma" game, which reflects his interest in the relationship between individualistic and collectivist models of rationality, motivated by his observation that rationality as defined at the individual level often leads to irrational behavior in the context of the system as a whole.[36]

Before enrolling at the University of Chicago at the age of twenty-six, Rapoport had established himself as an accomplished concert pianist. Like Bertalanffy, he was a philosopher at heart, although he believed very much in the enlightening power of science. While both he and Bertalanffy were listed as editors of the *General Systems* yearbook, it was Rapoport who was primarily responsible for combing volumes of relevant journals and compiling articles of interest to the general-systems community. Growing up in Russia where attitudes toward money were predominately negative, he was not particularly interested in applications of systems concepts in business, and his involvement in SGSR diminished as he saw the focus of interest shifting from biology, the behavioral sciences, and the philosophy of science to more instrumental concerns with systems engineering and management. He attributes his ambivalence toward operations research, management science, and related applications of systems concepts to a deep aversion to competition, which also motivated his attempts to elaborate alternative game/theoretical models to those in vogue with the military think tanks of the postwar period. However, he writes that Russell Ackoff, who worked as a consultant in both corporate and community environments, helped him to overcome his prejudice.[37]

Boulding describes Rapoport as "a man of unusually quick learning ability" and writes that he held a very high opinion of Rapoport's ability both as a thinker and as a teacher. Like most of the members of the general-systems group, Rapoport was a prolific writer, publishing twenty books and nearly five hundred articles. He was also a voluminous reader, involved on the editorial staff of numerous journals including the *Bulletin of Mathematical Biophysics, ETC: A Review of General Semantics, Behavioral Science,* and the *Journal of Conflict Resolution,* as well as the University of Michigan Press. In addition, he was a member of the Committee on Mathematics of the Social Science Research Council, and president of several societies including the International Society for General Semantics, the Society for General Systems Research, the Canadian Peace Research and Education Association, and Science for Peace.[38]

From Russia to Chicago

Like his father, whom he describes as "a Russian intellectual of the 'western' orientation," Rapoport was a socialist and an atheist, nurtured in the Russian tradition of soul-searching conversation. Like many of their generation, his parents rejected their Jewish religion and cultural traditions. Anatol was born in Lozovaya, Russia, on May 22, 1911, and immigrated to the United States in 1922 at the age of eleven, moving to Chicago where his father eventually became a storekeeper. Rapoport writes that it was his father's greatest regret that he had to become a businessman, where money was the sole measure of value. Rapoport had begun studying piano in Russia at the age of six and continued taking lessons in Chicago at the Chicago Music College and the Gunn School of Music. In 1929 he went to Vienna, where he studied music and supported himself by writing musical reviews. After devoting eight years to the study of music, he decided to switch careers, enrolling at the University of Chicago in 1937 as, he claims, the oldest freshman.[39]

He was admitted to graduate school in 1938, receiving a Ph.D. in mathematics in 1941. During the last year of his graduate work, he took his first course in mathematical biophysics from Rashevsky. At the time, he saw science as a revolutionary activity. Throughout his graduate career he was a member of the Communist Party, until, suppressing his pacifist convictions, he joined the air force upon completion of his degree. His first assignment was teaching mathematics and physics to aviation cadets, which prompted him to write an article, "Newtonian Physics and Aviation Cadets," that he submitted to *ETC: A Review of General Semantics,* edited by S. I. Hayakawa, who was to become, after Rashevsky, his second most important intellectual mentor, although they would part ways over the Vietnam War. Hayakawa's book *Language in Action* encouraged Rapoport to reevaluate concepts that Alfred Korzybski had introduced in his book *Science and Sanity,* which Rapoport had read while in the service but dismissed as pompous nonsense. Korzybski's concept of general semantics eventually provided the foundation for Rapoport's first book, *Science and the Goals of Man*. He continued his military career, as lieutenant and later captain, in Alaska and India, where he began to understand war as an institution that "fostered specialization and guaranteed careers."[40]

After the war, Rapoport applied for a position as instructor of mathematics at the Illinois Institute of Technology, where Hayakawa was on the faculty. Taking advantage of the GI Bill, he enrolled again at the University of Chicago. He met his future wife, Gwen Goodrich, at the Hayakawas' home; she and Mrs. Hayakawa had become friends through their work in the cooperative movement. They were married in 1949 and Gwen joined Rapoport at the University of Chicago, enrolling as a graduate student and working in the Industrial Relations Program. Rapoport worked very closely with Rashevsky, also a Russian emigré, from 1947 until 1954, when he left the University of Chicago. He started out as a research associate and eventually became an assistant professor of mathematical biology. One of his first assignments was to proofread a paper Rashevsky wrote on the interaction of two or more individuals, which became a catalyst for Rapoport's own work in game theory. Like Rashevsky's, Rapoport's interests branched outward from mathematical biology to the application of mathematical models in the study of human behavior.[41]

Rapoport joined Grinker's group in the late 1940s and Miller's Committee on the Behavioral Sciences in 1952, when he began to work closely with Gerard and Miller. His decision to leave Chicago in 1954 was partly motivated by the growing threat from the McCarthy "witch hunts." The University of Chicago welcomed the Jenner committee, which was responsible for investigating "un-American activities" on university campuses. When Hutchins left in 1951, Rapoport writes that the atmosphere at the university became oppressive, and that the future of the Committee on Mathematical Biology was uncertain. Two of the members of Rashevsky's committee were fired for invoking the Fifth Amendment in the hearings. Although Rapoport was not called to these hearings, the offer of a fellowship at CASBS was both timely and welcome. During that year he was involved with Gerard on several projects, including ongoing discussions of the work that the Behavioral Science Committee's "theory group" had begun. In addition, he was introduced to the work of Lewis Richardson, which formed the theoretical basis of the Peace Research Center he was to found in connection with Kenneth Boulding.[42]

In 1955 he moved to Ann Arbor, along with Gerard and other former members of Miller's committee, to join the MHRI, where he remained until 1968, as associate professor and later professor of mathematical biology at the University of Michigan. Along with Boulding, Rapoport helped to organize the first teach-in against the Vietnam War at the University of Michigan in 1965. He left the United States five years later as a result of his increasing frustration with the war machine and was offered a position at the University of Toronto, as professor of mathematics and psychology. After his official retirement in 1976, he traveled extensively as a guest professor in Berlin, Hiroshima, Louisville, Mannheim, Munich, and Bern, and as director of the Institut für Höhere Studien, founded by Paul Lazarsfeld and Oscar Morgenstern in Vienna, from 1980 to 1984, returning then to Toronto to teach peace studies. Reflecting on his departure from the United States, he writes that he did not feel that he could stay unless he were to become more actively engaged in opposing the war, and he did not think he was capable of becoming a full-time dissident. Nevertheless, the confrontation between the superpowers remained the central focus of his research and writing.[43]

Intellectual Passions

The most fundamental of Rapoport's intellectual passions was the application of abstract mathematical models to biological and social phenomena, which informed his interests in psychology, language, GST, game theory, and conflict resolution. When he first joined Rashevsky's committee in 1947, he began working on a mathematical theory of the nervous system, pointing out the relative autonomy of physico-chemical theories of nerve excitation, impulse propagation, and synaptic transmission from theories dealing with the structural properties of the neural network. While the former dealt primarily with matter and energy, the latter dealt primarily with probabilistic theories of networks, which Rapoport thought could be applied to such phenomena as the coding of sensory information, conditioning and learning, gestalt recognition, general theories of organization, and the evolution of adaptive behavior in society. His work along these lines was closely related to general theories of automata, servo-mechanisms, and communication systems that emerged in connection with the development of cybernetics and information theory.[44]

Rapoport's conception of GST grew out of his insight that analyses of form and content might be independent and that mathematical models of formal structure might provide a powerful unifying principle in the construction of theory. He writes, in describing his research interests at CASBS, that he had initially subscribed to the tenets of reductionism, which he defines as the assertion of "a continuity among the levels of organization through which reality manifests itself." According to this view, human behavior can be explained in terms of the fundamental laws governing the behavior of matter and energy. However, as a result of his interest in semantics, he began to acknowledge the symbolic dimension of human behavior as at least "quasi-autonomous," while perhaps also "isomorphic" with the physical dimension. His interest in the multidisciplinary approach to studying behavior reflects his quest for a fruitful union of analytic and holistic mentalities, which he suggested might parallel the union of the philosopher and the artisan that gave birth to modern science. For him, the year at CASBS was an opportunity to seek, if not conciliation, at least a *modus vivendi* between the positivistic, analytical orientation and the more "intuitive" or "humanistic" holistic approach; like Bertalanffy he emphasized the importance of methodological pluralism.[45]

General Systems Theory

Central to GST, as Rapoport conceived it, was the "new awareness of the fundamental interconnectedness of everything to everything else," along with the holistic notion of the whole as greater than the sum of its parts and related concepts of emergence and complexity. It was rooted in the concept of a "system" as a portion of the world capable of maintaining its identity in spite of continuous change in its surrounding "environment." The addition of the term "general" referred to the generalization of the notion of a system, to some extent as an extension of the concept of "organism." In connection with the study of "living" systems, it could thus be applied to the "subsystems" of an organism, including cells, organs, and tissues, as well as to the various "supersystems" containing individual organisms as subsystems, such as families, communities, and ecosystems. In seeking similar principles of organization at these different levels, Rapoport characterized GST as drawing upon the "creative exploration of analogies," an approach generally disparaged within the specialized scientific disciplines.[46]

Rapoport was particularly interested in analogies deducible from mathematical models, which, for him, illustrated the principle of "unity in diversity" and made it possible to bridge the cognitive and ethical dimensions of human existence. Exploring these mathematical analogies or "isomorphisms" was the primary task of a "general system theory" as he saw it. In overcoming the fragmentation of knowledge resulting from disciplinary specialization, Rapoport thought GST might contribute to a deeper understanding of the world in which we live. His work focused on examining and modeling large-scale patterns in such phenomena as growth and spread, steady state and equilibrium, evolving order or organization, conflict situations, and the relationship between individual motivation and group interaction.[47]

He acknowledged the wide divergence in the various approaches to GST, rooted in epistemological and value commitments. In contrast to the analytic orientation in industrial systems, he saw biology as the foundation of the holistic approach, reflected in the functionalist schools in sociology and anthropology that view society and culture as organismic wholes. Complications arise, however, in efforts to explain causation between different levels of organization, such as the biological and the psychological, or the individual and the social. Unlike Gerard, who tended to emphasize the organizing forces operating from the whole to the part, Rapoport suggested that the systems view highlights the interchangeability of cause and effect, and further that the perception of causal relations in one direction or the other is often a matter of policy or ideology.[48]

Rapoport's distinction between descriptive and normative systems approaches reflects a somewhat unique perspective. In his view, normative approaches conceive of systems as existing *for* something, which becomes the central focus of the investigation, while descriptive approaches view systems as intrinsically interesting in themselves. Thus, Rapoport describes the *instrumental* focus of systems approaches in industry as *normative,* because such systems are designed to serve specific goals. This definition diverges from current usage, which distinguishes between the instrumental focus of industry and normative (or ethical) concerns with the process by which ends are determined. On the other hand, conceiving the system as an end in itself, where the goal of the system is to preserve its own identity, which Rapoport characterizes as the *descriptive* approach, reflects normative and ethical considerations. A similar conflation of categories is reflected in his belief in the inseparability of conceptions of truth and goodness.[49]

The Symbolic Dimension: Values and General Semantics

Rapoport was particularly interested in what he called second-order knowledge—knowledge of self and of knowledge itself. Theories of cognition became one of his central preoccupations, underlying his work in such areas as general semantics, philosophy of science, psycholinguistics, and GST. This emphasis on cognitive theory also informed his understanding of the relationship between descriptive and normative approaches in decision theory, as well as his concern with the apparent incongruity between individual and collective rationality revealed in his analysis of non–zero-sum games. His findings in this area seemed to him increasingly relevant to the global situation. He considered the ramifications of the Cold War, manifested in the "nuclear arms race, ideological polarization, and the 'cancer-like' spread of war-related institutions through the entire fabric of both superpowers," to be the most formidable obstacle in the systems analysts' failed attempts at "rational" decisionmaking.[50]

Highlighting the impossibility of separating conceptions of truth from ethical considerations, Rapoport writes, "an unshakable belief that 'objective truth' is 'there' to be discovered is naive," suggesting that the search for truth is ultimately motivated by commitments to some underlying value system and referring to the work of Marx, Weber, and Mannheim on ideology, as well as Freud's work on the role of the subconscious. Like Boulding, he emphasized the futility of attempts to remove considerations of values in the behavioral sciences and, like Bertalanffy, he rejected the reductionism inherent in the behaviorist approach to psychology, which sought to make psychology a "hard science" by leaving out the subjective dimension of human experience. In attempting to understand the phenomena of consciousness, he identifies the act of recognition as the point of departure, reiterating his conception of a system as "something that is recognized as itself despite continual change within," rather than as "something consisting of well-defined constituent parts interacting in accordance with precisely formulated laws," as in physical systems. He suggests that the systems approach "put the psyche back in psychology when it was in danger of being sacrificed in the interest of conferring scientific respectability on the study of human behavior."[51]

Rapoport's understanding of the relationship between science and values was profoundly influenced by Korzybski's work on semantics. Rapoport's own books *Science and the Goals of Man* and *Operational Philosophy* addressed emerging views on the relativity of values in the context of Korzybski's work on the relationship between science and sanity. Rejecting the view that the function of science in society is purely instrumental, Rapoport argues that the process of scientific cognition is not separate from questions of ethics or morality. He suggests that the "relativists" did not really understand the true significance of the relativistic paradigm; while specific value systems may differ from each other, Rapoport cites Abraham Maslow's work as an attempt to identify universal values common to all humans.[52]

Beginning with the assumption that conflicting values are rooted in conflicting conceptions of truth and goodness, Rapoport suggests that science might provide an effective foundation for universal standards of truth. More difficult and dangerous are ideological conflicts, rooted in conflicting conceptions of goodness. If universal values could be identified, then, he suggests, differing conceptions of goodness become essentially questions of the most effective means for achieving such values. Such differences might then be resolved through the application of instrumental or scientific reasoning, providing a unity amid diversity. Although he recognized that science was not a value-free enterprise, he disagreed with those who argued that since science was a product of Western culture, it could not provide universal standards of truth. Drawing on Korzybski's conception of the dual nature of language as both survival mechanism and screen between humans and reality, as well as his claim that science is the language of sanity because its structure most closely corresponds with the structure of reality, Rapoport suggests that science viewed in this light includes an ethical component. In its identification of truth with shared experience, science could serve to integrate humankind more effectively than any other foundation such as institutionalized religion or identification with national, ethnic, or racial groups. All of the latter have a divisive component, splitting people into "us" and "them," while science, with its emphasis on shared cognition, does not.[53]

Game Theory and Conflict Resolution

At the same time, Rapoport was extremely critical of what he saw as the co-optation and perversion of both natural and social sciences by the military. He saw the institution of war as responsible for perpetuating conflict in both global and local contexts:

> No such infrastructure exists in the form of institutions designed and empowered to convert results of peace research, no matter how promising, into action. By contrast, a vast infrastructure exists in the form of institutions ready to apply knowledge produced by war research. However, the recognition of the institutional obstacles to the solution of the "problem" does suggest a fruitful direction of peace research.

Throughout the Cold War, he sought ways to facilitate more cooperative approaches to addressing human concerns, believing that the abolition of war as an institution was an essential prerequisite to addressing other global issues. He identified the aspiration and addiction to power as the primary source of violence. His efforts to articulate alternatives to what he called the "intellectualization of war," inherent in the military-industrial approach to systems analysis, are reflected in his work on individual and collective rationality, most fully developed in connection with game theory and the "Prisoner's Dilemma."[54]

Rapoport's interest in game theory focused on what he called "social traps," situations involving two or more decisionmakers, in which individual rationality supports different choices among given alternatives than collective rationality. He was particularly interested in finding out if people's choices would change as a result of their experience in such situations, based on the consequences of different kinds of choices. He thought that statistical analysis of behavior in such situations could provide insights into such psychological characteristics as "selfishness, altruism, trust, suspicion, tendency to exploit others' attempts at cooperation, willingness to retaliate or to forgive others' non-cooperation, etc." Even more interesting in connection with the relationship between biological and cultural evolution, he called attention to computer-simulation models that showed how cooperation might evolve within a population of egoists.[55]

Rapoport was particularly well-known for his work on the well-known "Prisoner's Dilemma," which Duncan Luce first shared with him during the year at CASBS. The dilemma begins with the arrest of two men for possessing stolen goods. Additionally, they could be convicted of burglary if one or both confessed. If neither confesses, they will both be sentenced to one year in jail. While the penalty for burglary is five years, the state's attorney offers to shorten the term to three years if both of them confess. If one confesses, and the other does not, the one who does will go free and the other will get five years. Thus, regardless of what the other does, it is more advantageous in either case for each individual to confess. However, the best option in collective terms is for both *not* to confess. Rapoport saw dramatic similarities between this situation and the global arms race, where the dictates of individual rationality would encourage "cheating" on arms agreements. He describes this conundrum as a counter-example to the "invisible hand" in Adam Smith's model of the free market, where the rational choice of each individual in pursuing his/her self-interest supposedly benefits everyone, and suggests that it might illustrate an opposite principle, an "invisible back of the hand," where individuals do not necessarily derive the greatest benefit by pursuing a "rational" self-interest. In addition to arms races, Rapoport mentions runs on banks and other panics as examples of similar social traps.[56]

With Albert Chammah, Rapoport conducted a series of experiments based on the "Prisoner's Dilemma" at the MHRI between 1962 and 1964, the results of which were published in their book, *Prisoner's Dilemma*. Against the dictates of classical decision theory, half of the participates initially chose cooperative strategies. While in the early stages of the game they seemed to learn that cooperation did not pay, with repeated iterations they would recognize the advantage of cooperation. In 1980 Robert Axelrod conducted a computer tournament based on the "Prisoner's Dilemma." Participants were asked to submit strategies for two hundred iterations of the game. Rapoport's strategy of choosing whatever his opponent had chosen on the previous play, which he called "Tit for Tat," was the winner. *Prisoner's Dilemma* focused primarily on descriptive aspects of decision theory, although Rapoport was equally concerned with the articulation of normative approaches in decision theory, which he addresses in *Fights, Games, and Debates* (1960) and *Strategy and Conscience* (1964).[57]

Both of these books emphasize the necessity of understanding the enemy, especially in terms of the historical roots of opposing ideologies. In his latter book, however, Rapoport was much more outspoken in his criticism of the defense community, particularly in connection with what he called the "intellectualization of war," the failure to extend rational analysis beyond a limited framework. He sought to criticize military strategy on its own ground, recognizing that the moral condemnation of war alone was inadequate to the task, easily dismissed as a failure to think rationally and to acknowledge harsh realities. For Rapoport, the rationality of the defense community did not go far enough in its failure to ascribe rationality to the opponent; he worked hard to expand the concept of rationality to support a more cooperative stance. In addition, he argued that it was important to recognize the subjectivity embedded in the conceptions of utility that informed the military strategists' models.[58]

In *The 2 x 2 Game,* Rapoport further develops his critique of classical game theory, which, like Adam Smith's model, draws exclusively on the concept of equilibrium, focusing on regulatory or negative feedback, and failing to account for the destabilizing influences of positive feedback. Rapoport suggests that such approaches ignore the interactions between decisions made by opponents, and thus exclude psychological considerations from decision analysis, resulting in an extremely limited and static conception of "rationality." Rapoport encouraged consideration of the extent to which each individual's interests might be coincident, opposed, or only partially opposed, along with such factors as the images that the players have of themselves and of each other, which are totally absent from the zero-sum models of classical game theory.[59]

In connection with his work on game theory, Rapoport became increasingly interested in theories of conflict. Drawing on his earlier work in semantics, he writes that the symbolic dimension—what people think about conflict—has a tremendous impact on the actual nature of human conflict. He categorizes different theories of conflict, including dialectical, social Darwinist, and strategic, along with theories of inner conflict developed in depth psychology. He points out that some theories tend to identify the source of conflict in the psychology of individuals, while others focus on social factors, reiterating the importance of recognizing causality in both directions. Even more interesting is his inquiry into the relationship between conflict among human groups and the perception of conflict between humans and nature reflected in such expressions as the "mastery of nature."[60]

He suggests that the "struggle for existence" is an inaccurate characterization of the natural world, pointing out that the success of a living system in conflict depends on the integration of its constituent parts and, further, that each instance of external conflict implies internal cooperation. In addressing the resulting boundary relationship between "internal" system and "external" environment, Rapoport asks what it means for a system to maintain its identity, under what conditions a system remains itself, and what might be acceptable criteria of identity. He notes that it is often unclear exactly how far identity extends and, further, that conflict means different things in different kinds of systems. He suggests that natural selection also operates on systems of cooperation and that the limitations in our perceptions result from our projection onto nature of our own cultural constructs.[61]

Enlightenment and Progress

In spite of his reservations about military appropriations of science, Rapoport was a firm believer in the Enlightenment ideal of progress, describing "positivistic science" as his religion. For him, the Enlightenment initiated a process of redefining values and the peace movement represented the continuation of this process in the twentieth century. He acknowledged the growing disillusionment with progress as it became associated with the growth and spread of technology, increasingly diverted to serve the global war machine. In addition, he recognized the destructive aspects of even "peaceful" uses of technology in environmental degradation and, more importantly, in the concentration of power in the hands of a few. He understood that the distrust of technology carried over into a distrust of science. And yet, he still championed the positive contribution of science as an improved mode of cognition. In contrast to the potential good offered by science was the evil he saw in treating human beings as objects, as means to an end, which was reflected in military terminology and carried over into the language of industry.[62]

For Rapoport, using people as means to an end is the same thing as having power over them. Thus, the ultimate source of evil is the aspiration to power over people, which he saw as an addictive need, manifested in the extreme in the arms race. Progress, like democracy, can only exist if concentrations of power can be prevented. Even in constitutional democracies, he points out that concentrations of power and the resultant instrumental use of human individuals persist in the realms of competitive business and politics. And even without direct coercion, people cannot only be persuaded to buy things, but also to identify their interests with those of the power elites. Referring to the work of Johann Galtung, he notes that internal stability based on an apparent absence of conflict can amount to a form of "structural violence," an understanding that informed his continued interest in the role of conflict and cooperation in conceptions of social good.[63]

Central to Rapoport's argument in *The Origins of Violence* is the contradiction between two fundamental aspects of human existence. To be human, he says, means to seek autonomy. On the other hand, the survival of humanity as a whole is increasingly dependent upon a greater degree of integration. In seeking compatibility between these two imperatives, Rapoport suggests that the faculty of self-examination provides a possibility for achieving integration without jeopardizing autonomy. In attempting to overcome dichotomies between various conceptions of "us" and "them," he suggests that underlying all such dichotomies are incompatible conceptions of truth and goodness. Appealing to the systemic idea of unity in diversity, he proposes two candidates for universal human values: (1) living in peace with others and (2) guaranteeing universal human rights. Rapoport also recognizes tolerance as an important concomitant of shared values, acknowledging the difficulty of overcoming deeply rooted prejudices. While he thought conflicts could be resolved if people could cultivate tolerance for other value systems, he concedes that such a task is most difficult in connection with conceptions of good and evil, giving the example of attitudes toward women's sexuality as an area where tolerance seems particularly unattainable.[64]

Nevertheless, looking at humankind as a living system with the potential for evolution, Rapoport suggests that maturation of the human species might entail an expansion of the range of identification. His perspectives on self-examination and expansion of identity echo the expanded conception of self reflected in deep ecology and Buddhist philosophy. There seems to be a widespread and passionate resistance to such formulations, as the separate ego strives to maintain the boundary between self and other. There are also, of course, small indigenous peoples striving to maintain their independence from the global corporate "megalopoly," which is itself ultimately bound up with the self-perception of those in control. Rapoport highlights the critical role of perception in questions relating to system boundaries and identity, which seem to plague systems theory, upholding the possibility of an expanded identification with the system as a whole that would neither be achieved by force and coercion nor entail the suppression of the individual.

In conversations with Rapoport in his home in Toronto, I was impressed by the strength of his belief in the general goodness of humanity coupled with his passionate dislike for the military-industrial complex. In reading through his work, I developed a tremendous appreciation for his efforts to articulate meaningful alternatives to the zero-sum rationality of military strategy. While systems theory is easy to dismiss on the basis of some of its excesses, there are valuable insights to be gained from systemic perspectives, and Rapoport's work offers a significant contribution. It is interesting to reflect upon his relationship with Gerard and Miller, whose work had a significantly different political orientation. Nevertheless, the three of them worked quite closely together for fifteen years and Miller provided substantial support for his work. Like the society they founded, they embodied their own unique version of unity in diversity.

JAMES GRIER MILLER (b. 1916)
The Behavioral Sciences and Living Systems Theory

Like Gerard, who remained one of his closest associates, James Grier Miller writes that his "scientific and professional activities have centered around the single theme of integrating knowledge about biological and social systems." He studied psychology at Harvard, when it was still taught through the Philosophy Department, where he worked closely with Alfred North Whitehead. Miller writes that Whitehead encouraged him to work toward an integrative conceptual framework for the biological and social sciences. When he came to the University of Chicago as chairman of the Psychology Department in 1948, the department was in the unique position of reporting to both the biological and social-science divisions. At the time, Lowell Coggeshall was dean of biological science and Ralph Tyler was dean of the social-science division. Both were involved in the formation of the Committee on the Behavioral Sciences, which was initiated in 1949 under Miller's direction. The idea for the committee came from Enrico Fermi; along with many of the scientists involved with the development of the atomic bomb, Fermi sought to address the roots of conflict in human behavior. Echoing Whitehead, he encouraged Miller to work toward a synthesis of concepts and principles from biological and social sciences.[65]

Miller was skilled as an administrator, providing institutional support and acting as a catalyst for many developments in the behavioral and information sciences. After chairing the Committee on the Behavioral Sciences at Chicago from 1949 to 1955, he moved to the University of Michigan at Ann Arbor, turning down an invitation from Robert Oppenheimer to join the Princeton Center for Advanced Study in order to become founding director of the Mental Health Research Institute in association with the University of Michigan Medical School. Miller often characterized MHRI as a "general systems" institute, and it was the institutional center for most of the early activities of the SGSR. In 1967 he left Michigan for a position as vice president for academic affairs at the newly established Cleveland State University. He moved to Louisville, Kentucky, in 1973, as president of the University of Louisville, which he tranformed from a private municipal university into a state university, increasing the enrollment from 9,000 to 20,000 by the time he left in 1980 and establishing a Systems Science Institute that was one of the major "systems science" programs in the country.[66]

In conjunction with his administrative ability, Miller's *Living Systems*—a systematic synthesis of years of conversation and collaboration of scientists and scholars from a diverse array of disciplines—offers a substantial contribution to the development of systematic cross-disciplinary inquiry. At the dedication of the James Grier and Jessie Louise Miller Information Technology Center at the University of Louisville in March of 1995, former vice president and managing director of the International Society for the Systems Sciences, Linda Peeno, described Miller's contribution as "building bridges across the disciplines, creating new ways of communicating and sharing information, exploring methods for bringing all this to bear in the examination and resolution of the increasingly complex and demanding issues of the day."[67]

Unlike Bertalanffy, Miller saw no difference between systems science and cybernetics. Although Bertalanffy was the one who articulated the task of GST, in its "scientific" aspect, as discovering formal similarities or "isomorphies" between systems at different levels of organization, it was Miller and the behavioral-sciences group that accomplished the most along these lines. Except for his work on growth and cancer, in which he sought to formalize general principles, Bertalanffy was generally more concerned with the philosophical aspects of GST. More in alignment with Rapoport and Boulding, he emphasized the emergent properties of the psychological or symbolic dimension of human behavior. Boulding often contrasted his own view of systems, which he described as ecological and evolutionary, with Miller's approach, which Boulding thought was more "physiological." The distinction between these views is elusive, yet essential to understanding their respective implications for social theory.[68]

Rapoport writes that Miller was "most enthusiastic" about GST. In a retrospective videotaped conversation with Margaret Mead, who was actively involved in the early development of SGSR, Miller comments on how people tend to see systems theory as inhumane, with the intention of making humans into machines, when actually this is the reverse of its actual goal. With his training in both psychology and psychiatry, Miller focused on mental health as an area that was ideally suited to systemic investigation, exploring the relationship between the individual and his/her environment. He suggested, further, that the concept of mental health could be extended to include such human groups as families, work teams, institutions, and whole societies. His conception of GST was shaped most profoundly by Gerard's scheme of comparing the categories of structure, function, and evolution at different levels of organization in living systems, from the cell to the total biosphere. Building on twenty-five years of collaborative discussions, he ultimately expanded Gerard's initial three categories to a total of twenty subsystems that he considered essential for any living system, divided into three groups on the basis of whether they were responsible for the transfer of matter-energy, the transfer of information, or both (see Table 7.1, p. 182).[69]

This concern with information as distinct from matter-energy was the hallmark of the period, central to the evolution of both cybernetics and information theory. Like Gerard, Miller's interest in the processes of information transfer at both organismic and social levels is reflected in his involvement with the use of computers in education and management. He witnessed the evolution of the computer from its inception through his association with Fermi, who was involved with the development of Eniac, the first generation of the modern computer. In connection with Miller's work on information overload, a major focus of his research at MHRI, he became involved with the design and implementation of the first computer networks, predicting in 1966 that such networks would eventually become international.[70]

As an undergraduate and graduate student at Harvard between 1935 and 1944, Miller was trained under some of the most influential thinkers of the period, and was on the cutting edge of the development of the relatively new fields of psychology and psychiatry. He worked most closely with Whitehead. Other significant mentors included Gordon Allport, Edwin Boring, Walter Cannon, Lawrence Henderson, and Henry Murray. The patterns of his life and thought thus reflect significant cultural currents that shaped the thinking of the postwar generation of scholars. He writes in his preface to *Living Systems* that the dominant metaphors of the twentieth century were drawn from Einstein's relativistic field theory and were reflected in Whitehead's work, as well as in such developments as gestalt psychology and GST. Central to this orientation was a recognition that "the interrelationships among the coacting components of an organized whole are of fundamental importance in understanding the totality."[71]

Life and Thought

James Grier Miller was born in July 1916, in Lakewood, Ohio, where he also went to high school and met his future wife, Jessie Luthi. His father was a minister, and he himself began his university career studying to become a minister at Columbia Bible College. Changing course, he enrolled at the University of Michigan in 1934, majoring in psychology. During that year he was a lab assistant for an introductory course in experimental psychology. In the fall of 1935 he transferred to Harvard, while Jessie, who had also been enrolled at the University of Michigan, transferred to Radcliffe. They were married in September 1938. Miller graduated summa cum laude in 1937, with the highest GPA in his class, receiving his master's degree a year later. From 1938 until 1942 he attended Harvard Medical School. During that period he published his first book, *Unconsciousness,* and began his doctoral research on subliminal perception and information processing in the brain. He was appointed a junior fellow in the Harvard Society of Fellows, serving two terms from 1938 until 1944.[72]

Throughout Miller's years at Harvard, Whitehead was a major mentor and close friend. Drawing a parallel with the theoretical work of Arthur Eddington and James Jeans in cosmology, Whitehead suggested to Miller that a similar theoretical integration in the biological and social sciences, a "general theory of living systems," would contribute significantly to further development in those fields.

Whitehead's "philosophy of organism," which Miller identifies with the more recent "philosophy of system," was central to Miller's work. Whitehead's orientation represented "an entirely new approach" to the study of complex systems, reflected in the work of such scholars as J. Willard Gibbs, Henri Le Châtelier, Hubert H. Bancroft, Cannon, and Pareto, who all agree that such systems can not be understood in mechanical terms, but instead require an examination of patterns and trends. As Miller writes in a passage from *Living Systems:* "All nature is a continuum. The endless complexity of life is organized into patterns which repeat themselves at each level of system." Miller begins the last section of the book, on the continuity of science, with a quote from Spinoza: "It is impossible that man should not be part of nature, or that he should not follow the general order."[73]

At the end of his second term in the Society of Fellows, in July 1944, Miller joined the army. He was assigned to the Office of Strategic Services (OSS) Assessment Unit, originally headed by Henry Murray (his former mentor at Harvard) and then briefly under Miller's command in the latter part of 1945. Based on papers that had previously been classified, Miller read sections of his memoirs from this period at a celebration of his eightieth birthday in connection with the fortieth anniversary of the official founding of SGSR. His accounts of the assessment process and the administration's difficulties in keeping up with the OSS recruits were revealing and highly entertaining. In January 1946 he left the army and was appointed the first chief of the new Clinical Psychology Section in the Central Office of the Veterans Administration in Washington, D.C., setting up the VA's first national clinical-psychology program. Miller notes that 25 percent of the trained psychologists in the country, about two thousand of them, were involved in this program, which provided a significant boost to the development of the discipline. At his request the American Psychological Association established the Ph.D. as the appropriate level of training for clinical psychology, and over forty universities joined a national program of doctoral training in clinical psychology with financial support from the government. He remained with the VA through 1947. At the same time, during the 1946–1947 academic year, he was assistant professor of clinical psychology in Harvard's new Department of Social Relations, chaired by Talcott Parsons.[74]

Chicago

In January 1948 Miller joined the University of Chicago as chair of the Department of Psychology. In addition, he was professor of psychiatry in the Department of Medicine. He was invited a year later to join the Innominate Club, a faculty research group whose members were mostly natural scientists, including Enrico Fermi, Willard Libby, Leo Szilard, and Harold Urey. Pointing out that natural science had developed rapidly with the formulation of general theories, Fermi and Szilard suggested a similar strategy for the study of human behavior. Fermi, in particular, urged Miller to work on integrating biological and social knowledge, which he hoped would lead to a better understanding of human behavior and "prevent human beings from destroying themselves by nuclear warfare." Although Miller writes that he was doubtful whether biology and the social sciences were "sufficiently advanced for such an endeavor," Fermi requested funding for the project from Hutchins, who asked the respective deans of the biological and social-sciences divisions, Coggeshall and Tyler, to assist Miller in forming an interdisciplinary research group of senior faculty members to investigate the possibility of further work along these lines.[75]

Miller writes that he had been trying since 1947 to come up with a term that would adequately describe the study of human behavior and that would also be acceptable to both biological and social scientists. Also, there was a concern that some people, particularly those associated with funding sources, might confound social science with socialism. Miller points out that "comments of certain senators during the 79th Congress showed that some of them actually labored under such confusion." On October 23, 1949, he wrote a memo to Robert Havighurst suggesting that the new interdisciplinary group be called the Committee on the Behavioral Sciences, which he claims was the first use of the term in its current connotation.[76]

Donald Marquis, chair of the Department of Psychology at the University of Michigan and a close friend of Miller's, helped formulate the goals of the committee. In addition, he played an important role in shaping the Ford Foundation's support of the behavioral sciences through his involvement with the planning for the Center for Advanced Study in the Behavioral Sciences. He had been part of the original committee appointed in 1948 by the Ford Foundation to formulate a plan for funding research in the social sciences. According to Miller, Marquis suggested that the foundation start a program in behavioral science. In 1951 Rowan Gaither was appointed to develop this program and Marquis was appointed as a consultant, along with Hans Speier, chief of the social-science division of RAND. Bernard Berelson, professor of library and social sciences at the University of Chicago, became the senior staff member for the development of the program and was later appointed director of the foundation's Behavioral Sciences Division, which was created in 1952. Tyler, who had been very supportive of Miller's work at Chicago, was appointed as the director of CASBS. Miller writes that the funding made available through this program gave worldwide currency to the term "behavioral science."[77]

Reporting to Tyler, the Chicago Behavioral Science Committee held planning sessions and preliminary conversations between 1950 and 1952. Miller writes that they "began to see promise in the general systems theory proposed by Bertalanffy and others." In 1951 Miller circulated a manuscript entitled "The Behavioral Sciences," which he describes as the "first draft of what would ultimately become *Living Systems*." In it he addressed the relations between science and the humanities as well as the use of scientific method in the behavioral sciences, formulating an initial set of basic principles that were relevant to both biological and social systems. Beginning in October 1952, a theory group was organized and began meeting on a weekly basis until 1955, continuing after that at MHRI. The participants at the first meeting included Miller, Gerard, and Rapoport, along with Donald Campbell, David Easton, Donald Fiske, Ward Halstead, Henrietta Herbolsheimer, Jacob Marschak, Roger Sperry, Calvin Stillman, and Sherwood Washburn. Among those who joined the group later were Robert Crane, Richard Meier, and John Platt, who subsequently moved to Michigan to join Miller at MHRI.[78]

Michigan and Beyond

Miller worked hard to establish a behavioral-science institute at Chicago. This project was authorized by the university in 1953, and he was beginning the process of raising funds when he was approached by Raymond Waggoner, chair of the Department of Psychiatry at the University of Michigan School of Medicine, who invited Miller and his group to come to Ann Arbor. Waggoner had known Miller while he was in the OSS and managed to obtain a commitment from the Michigan legislature to construct a building and provide ongoing support for the institute. At the suggestion of Harlan Hatcher, president of the University of Michigan, the name was changed to the Mental Health Research Institute because there was substantial funding available for research in that area. Although Miller continued to argue for the relevance of broad-based theoretical research to the mental-health field, the institute was eventually removed as a line-item in the state budget in 1967.[79]

Gerard and Rapoport moved to Ann Arbor in the fall of 1955, followed a year later by Crane, Meier, and Platt. Within about ten years, the institute had grown to include about a hundred researchers representing a broad range of disciplinary orientations. As Rapoport describes the layout of the building, the "lower" levels of organic research were carried out on the lower floors, while research on the "higher" levels of organization (individuals, small groups, etc.) was housed on the upper floors. It was a "beehive of activity," generating research on a broad range of topics more or less directly associated with mental health. In addition, it became the administrative center for the newly founded Society for General Systems Research, publishing the *General Systems* yearbook, as well as the *Behavioral Science* journal, beginning in 1956. The theory group, with Gerard, Miller, and Rapoport as its core, continued meeting on a weekly basis for the next twelve years.[80]

Miller's major research during this period was on "cross-level" studies of "information input overload." In 1963 he presented his findings on the topic to the Association of Medical Colleges at their first Institute on Medical School Administration, suggesting that information-processing technology could be useful in administrative contexts. The medical director of the association asked Miller for more specific suggestions, leading to the establishment in 1964 of the Interuniversity Communications Council (EDUCOM), with Miller as the first chief administrator. EDUCOM was incorporated in Michigan and headquartered at MHRI, initiating the development of the Bitnet and the Internet. In July 1966, 180 representatives from education, government, and independent organizations met in Boulder, Colorado, to assess the desirability of an educational communications system. The first statewide regional network was established in Michigan, based on a plan developed in part by Miller. The report on a 1966 study of information networks conducted by EDUCOM opens with the following: "Information is the essential ingredient in decision making. The need for improved information systems in recent years has been made critical by the steady growth in size and complexity of organizations and data."[81]

In 1967 Miller accepted a position as vice president for academic affairs at Cleveland State University, becoming provost in 1970. During this period he was invited by Gerard to present a paper at the University of California at Irvine on "a systems analysis of the flow of administrative information in colleges and universities, addressing the issue of whether a systems approach, including the use of information processing technology, could enhance the quality and increase the efficiency of education and research in the new university." In 1971 he was appointed vice president in the Washington office of the Academy for Education Development, an international program using instructional technology. In addition, he was a consultant for the U.S. State Department, developing instructional systems for the governments of Brazil, El Salvador, Cambodia, Indonesia, Laos, Malaysia, Philippines, Singapore, South Vietnam, Thailand, and India. He was also a consultant to the Special Action Office for Drug Abuse Prevention in the White House and lecturer in psychology and behavioral sciences at John Hopkins University. From 1973 until 1980 Miller was president of the University of Louisville, more than doubling the enrollment and significantly improving the quality of the educational program. During the summers of 1973 and 1974 he was a fellow at the International Institute for Applied Systems Analysis, chairing a program on methodology and systems theory. In 1978 he published *Living Systems,* a synthesis of twenty-five years of collaborative work. From Louisville he moved to San Diego and established the University of the World, using global networks to make educational technology available to countries throughout the world.[82]

The Committee on the Behavioral Sciences

In 1954 Miller wrote: "About five years ago . . . , we originated the phrase 'behavioral sciences,' to refer to all the overlapping biological and social disciplines concerned with the study of behavior." The aim of the Committee on the Behavioral Sciences was to "build a program of empirical research around general theory." In constructing such a theory, they began with models from the physical sciences. Although he refers to GST as a useful starting point for such a task, his orientation differs markedly from that of Bertalanffy, as illustrated in his claim that "all psychological phenomena are essentially naturalistic, and can ultimately be translated into the principles of physics." Like Bertalanffy, the committee sought to improve communication between the various disciplines, although in general their approach tended to be somewhat more reductionist. Miller compared the work of the committee to developments in such fields as social physics, organization theory, and gestalt psychology, referring specifically to Talcott Parsons, Herbert Simon, Chester Barnard, W. C. Allee, and A. E. Emerson; the "dynamic systems" of Freud, Henry Murray, Kurt Lewin, and Tolman; and the interdisciplinary efforts of such institutions as the Yale Institute of Human Relations, the Harvard Department of Social Relations, and the Michigan Social Science Research Center.[83]

The initial incarnation of the behavioral science committee, the Committee on Neural-Mental Problems, was convened in the fall of 1949 to look into the possibility of integration between the biological and social sciences. The first two meetings were held at Gerard's home. Although some expressed doubts that social scientists could effectively team up with biological scientists, by December the renamed Committee on the Mental and Behavioral Sciences proposed the establishment of an institute of behavioral sciences at the University of Chicago, which would "correlate activities of those interested in the Mental Sciences within the social and biological sciences divisions." Negotiations on the proposed institute continued over the next three or four years, while the new committee began meeting on a weekly basis in the spring of 1952, with participants from the fields of history, anthropology, economics, political science, sociology, social psychology, psychology, psychiatry, medicine, physiology, mathematical biology, and occasionally physics and philosophy.[84]

The proposed institute would build on previous attempts to establish integrative programs in social-science research, particularly empirical approaches to such research. Minutes from a 1959 meeting of the National Research Council's Committee on the Behavioral Sciences reflect a fairly reductionist orientation; their definition of the behavioral sciences excluded areas of traditional social science that are predominantly historical or philosophical and included fields not generally considered part of the social sciences. They identified psychology as a key discipline in the new field, while sociology was characterized as "historical, rational, or reformist in tone, and hence [not to] be regarded as a sector of behavioral science." Further, behavioral science "encompasses observational and/or experimental investigations of human behavior, the biological and situational bases of such behavior, comparative psychology insofar as this bears upon the understanding of human behavior; [and] the construction of abstract models to represent regularities in the data." Such models were to be constructed with the aid of computers and other techniques.[85]

Along similar lines, Gerard describes his conception of the scientific approach to behavior as focusing on "finding regularities between and within classes of phenomena rather than being concerned with the individual event per se." For Gerard, science entails theoretical generalization rather than detailed description or observation. To the extent that attention is focused on specific events, the investigation is not scientific. He describes knowledge as progressing from observational to taxonomic to structural to dynamic to holistic formulations, suggesting, for example, that electro-physiological studies on the action of neuron loops and assemblies are more relevant to the study of human behavior than statistical tools in sociology or commodity-price graphs in economics. Within these constraints, he writes that behavioral sciences are "concerned broadly with the understanding of human behavior" and, revealing his generally paternalistic orientation, suggests that such research could be applied in the "formation and survival of human institutions" as well as in relation to the "human behaviors involved in their creation and maintenance."[86]

In May 1951, before the committee began its regular meetings, Miller had distributed a manuscript entitled "The Behavioral Sciences," in which he laid out his conception of the aims of the group. He emphasized the "potential social importance of sound principles of human relations," which could be applied in such areas as industrial relations (maximizing production), racial and cultural relations (preventing discrimination and violence), crime, delinquency, personal maladjustment, political corruption, and familial disorganization. Most importantly, he hoped that it might contribute to "maintaining peace and combating the threat of mass destruction."[87]

Miller argued that the scientific method did not necessarily conflict with the method of the humanities. With its "set of procedures for orderly understanding, prediction, and control of natural phenomena," science could enhance the goal of the humanities, which he described as the "appreciation of nature and study of the values in it." Echoing Rapoport, he believed that science was rooted in democratic public agreement. While biologists tend to view the social-science fields as unscientific, Miller points out that social scientists perceive the biological approach to human and animal behavior as "highly constricted . . . , slighting the effects of the environment on the organism, the results of learning, memory, and reasoning, the influences of social norms and pressures, and the significance of values." Nevertheless, Miller believed that social phenomena would eventually be translated into biological terms, in the same way that biological phenomena were increasingly being explained in physical terms.[88]

Since psychology was "gravely suspect" in the minds of "hard-headed scientists" as a "modern refuge for the religious concept of the soul," Miller was anxious to demonstrate the scientific legitimacy of the field, without eliminating its humanistic element. He describes the conflict between the behavioristic and phenomenological approaches to psychology, with their respective emphases on the external/objective and internal/subjective frames of reference, as a contemporary form of the classical mind-body dilemma. In attempting to synthesize the two approaches, Miller suggests that the two frames of reference are two aspects of a single phenomena, reflecting an "isomorphic" relationship between subjective experience, objective behavior, and neural process. Of course the question remains as to which level is considered causal; the objective approach emphasizes physical causality in contrast to the subjective emphasis on the role of consciousness and will.[89]

Miller thus conceived of behavioral science as an attempt to integrate studies of the physiological, behavioral, and subjective, experiential dimensions of human life. As such, it would incorporate research from physiology, cybernetics (in electronic models of brain function), experimental psychology, mental measurement, learning theory, studies of perception (including gestalt psychology as well as studies of the social determinants of perception), self theory and phenomenology, psychoanalysis, and the social and cultural influences on behavior (including group dynamics, social norms and roles, symbolization, and communication). The remainder of his 1951 manuscript was devoted to a detailed analysis of principles that could be applied to different aspects of human behavior and generalized to all living systems, including, for example, homeostasis, anxiety, constancies, learning, growth, change, and communication. Such principles are eventually articulated in terms of the twenty subsystems of Miller's living systems theory.[90]

Most significant is Miller's discussion of the executive function—the "decider" in his later work—which is responsible for the "overall control and direction of the organism." He compares this function with the "combat information center" of a battleship, as well as to the function of the executive in large organizations. Such a function is highlighted in cybernetic models that rely upon a "governor" to select the appropriate response or "output" for any given stimulus or "input." This function also makes it possible to explain the phenomenon of learning, in evaluating the results of previous choices on the basis of their effectiveness in the pursuit of a particular goal. Miller describes the decisionmaking function in terms of "interacting fields of force," within the three primary parameters of truth, goodness, and beauty. Suggesting that the "most difficult task of the organism's executive is bringing about harmonious decisions involving all of these incommensurable modalities," he mentions the conflict between the determinism inherent in the "truth" modality and the freedom of the will implied in the "goodness" modality. Revealing his deterministic bias, however, Miller writes that "there is experimental proof that [subjects] can believe they are choosing freely and voluntarily when the conditions are such that their reactions are wholly determined by external factors."[91]

In addressing the executive function at the level of social organizations, Miller notes that the use of experts in the decisionmaking process should be carefully monitored to guard against "trade unionism or dogma," the tendency among professionals to agree to "call something a fact, regardless of the strength of evidence for it, in order to strengthen their profession." He suggests, nevertheless, that "the laws should be written so that, unless such invalidating circumstances are found, the testimony of real experts would be accepted in a mandatory fashion for the public good." He proposes a kind of Hippocratic oath for behavioral scientists as the "only practicable restraint to prevent misuse of their power." In describing their role in the maintenance of peace, he envisions "widespread public educational, propaganda, or advertising campaigns . . . stressing the brotherhood of man . . . [and] strengthening the desire for peace in the value systems of the public." While he concedes that "ultimate power should not be taken away from Congress and placed in the hands of experts," he fails to consider the potential for collusion and the undue influence of commercial interests in both science and government.[92]

Another important task for Miller was emotional education, finding ways to minimize hostile reactions in individuals through the study of group dynamics and the improvement of problem-solving skills. Citing the work of Gordon and Haigh, he writes that in order to live together, people need to communicate. Significantly, they note that communication is a mutual process, involving the active participation of both speaker and listener, and that communication is complete only when the listener can "restate his opponent's position and arguments to the satisfaction of his opponent." Echoing Rapoport's work on individual and collective rationality, they have a fairly optimistic view of the possibilities for mutual understanding that can result from such a process: "Listening and understanding the other person does not mean agreeing with him . . . (but discovering) together the misunderstandings, fears, and tensions which prevent the two from getting together on those issues *where agreement will equally serve the needs of both*." Further evidence of this optimism is Miller's suggestion that leadership roles should be filled by "cooperative individuals with a passion for anonymity," whose emotional lives are "sufficiently stable that they can be happy with the satisfactions derived from service to mankind."[93]

As the theory group continued to meet, they gradually began to focus on systems and cybernetics concepts relating to the different levels of biological and social systems, developing cross-level hypotheses. At the annual meeting of the American Psychological Association in 1953, five member of the Behavioral Sciences Committee presented a symposium addressing their collective work, entitled "Profits and Problems of Homeostatic Models in the Behavioral Sciences." In his introductory paper, Miller discussed the evolution of the behavioral-science concept and the possible applications of basic research on systems, along with general areas of agreement among the committee. He noted that most of them thought it would eventually be possible to use the same dimensions and units in the behavioral sciences as in the physical and biological sciences, a critical tenet of his living systems theory. Gerard presented a paper on "The Organismic View of Society"; Rapoport on "Some Mathematical Models of the Spread of Information Through a Population"; David Easton on "Limits of Equilibrium Models in Social Research"; and Donald Campbell on "Adaptive Behavior from Random Response."[94]

At the twenty-fifth anniversary of the University of Chicago's Social Science Building in 1955, Miller presented a paper entitled "Toward a General Theory for the Behavioral Sciences," discussing the progress of the behavioral-science group. He noted that some people had found the collaborative approach uncongenial, "either because of well-developed patterns of solitary work, or because of ego involvement with a single point of view and fixed commitment to it." Again, he points out that they tried to state their hypotheses in quantitative terms, employing dimensions from the natural sciences relating to the centimeter-gram-second (CGS) system, an essentially "reductionist" approach in limiting the scientist's parameters to phenomena that can be measured in the Newtonian dimensions of distance, mass, and time. At this point, they had adopted the term "general behavioral systems theory" to describe their work, focusing on living systems as "bounded regions in space-time, involving energy interchange among their parts, which are associated in functional relationships, and with their environments." Echoing Bertalanffy, he notes the open nature of living systems as their most significant characteristic, although their respective interpretations of the implications of such openness are markedly different.[95]

Miller writes that "all behavior can be conceived of as energy exchange within an open system or from one such system to another," describing the values motivating behavior in terms of "the strains within the individual resulting from his genetic input and variations in the input from his environment," where the relative urgency of these strains determines the hierarchy of values. This leads to a discussion of coding, the process linking exchanges of information and matter-energy. While biology is generally concerned with transfers of matter-energy and the social sciences with transfers of information, Miller thought the development of information theory provided a way to connect the two dimensions, specifically in relation to information processing in the brain. Thus the symbolic dimension of human experience might be explained in terms of energy transformations linked to the information-coding process, which could be ultimately described in CGS units. In further developing this model, Miller used computer analogies to represent the organizational structure of internal mental processes, reflected ultimately in the subsystems of his living systems model.[96]

The initial conceptual framework for the behavioral-science group came from Gerard's scheme of investigating the three central aspects of all living systems—structure, function, and evolution—at the level of the cell, organ, organism, group, organization, and international system. Analogies between different levels of organization with respect to these three aspects would then provide a means of integrating biological and social dimensions of behavior. For Rapoport, this framework highlighted unity in diversity, providing "a link between an optimistic epistemology and an optimistic ethos, that is, a rationale of a possibility of progress." Most of the early work of the theory group involved a preliminary classification of proposed concepts and an elaboration of analogies. Examples suggested by Donald Fiske include examination of the "sensitivities of organisms and groups, capacities of organisms and groups, limitations of behavior, hierarchy of behavioral acts, interactions of reaction tendencies, control systems (inhibiting or suppressing factors, both within and outside organism), and integration of behavior (organizing or executive function)."[97]

In 1954 Gerard reviewed the minutes of the theory group meetings and summarized the progress they had made in a report distributed to the members of the Committee for the Behavioral Sciences. The contents of the report included (1) analogies and formal identities; (2) formal models and formal identities, on the use of mathematical models and distinguishing models from statistical description; (3) general behavioral systems theory (GBST), an explanation and standardization of dimensions; and (4) mathematical models in the social sciences, addressing critiques of such endeavors. Based on his model of the developmental stages of knowledge from the taxonomic to the holistic, Gerard suggested that mathematical models became increasingly useful in the latter stages as the "precision of identifying units, properties, processes and relations increases."[98]

Gerard describes the basic hypothesis of GBST as the assumption of "certain formal characteristics of systems in the real world which are similar at molecular, cellular, organic, individual, small group and societal levels." Further, and central to the project of the SGSR, he suggests that "models developed for one level of the behavioral sciences will prove applicable at other levels." For Gerard, of course, the emphasis was on the applicability of models developed in biology for "predicting regularities in societal behavior," although he concedes that there is "no implication that the ultimate equations will be identical." Since the usefulness of models depends upon the degree of similarity of the situations they describe, he suggests that the three primary types of interaction in biological systems are mechanical, transportational, and transmissive, and then proceeds to consider whether or not society is sufficiently different from organisms that the kinds of interacting forces would not be encompassed in these three categories.[99]

According to a second fundamental hypothesis of GBST, a complete explanation of a system at any level must consider related systems at both higher and lower levels. Gerard gives the example of fluctuations in the psychological performance of the individual, which requires an exploration of neurological variation. Reflecting his reductionist bias, he does not address the social context, unlike Bertalanffy, who focused almost exclusively on the latter. Although ideological commitments often place the emphasis in one direction or the other, systems theory in general highlights the mutual causal relations between part and whole. In addressing critiques of the use of mathematical models in the social sciences, Gerard suggests that such models might help to identify the most significant variables in any given situation.[100]

The Mental Health Research Institute

While Gerard and Rapoport were in residence at CASBS, Miller was preoccupied with negotiations for the Mental Health Research Institute. Although he had been invited by Oppenheimer to join the Princeton Center for Advanced Study, he chose instead to pursue his vision of a behavioral-science institute. Gerard and Rapoport continued to meet during that year with other fellows who had been associated with the behavioral-science theory group, joined occasionally by Miller when he could come out to California. In the fall of 1955 the three of them formed the core of the newly established MHRI, with Miller as director and Gerard as director of labs. All three had faculty appointments in the Department of Psychiatry at the University of Michigan. They were joined a year later by Crane, Meier, and Platt. The theory group continued to meet for the next twelve years, until Miller left Ann Arbor to move to Cleveland in 1967.[101]

Although a number of interdisciplinary institutes were established during this period, MHRI was unique in its emphasis on integrative theory. In addition to financial support from the state of Michigan, their research was funded by grants from the U.S. Public Health Service, the armed forces, foundations, and industry. Officially, the purposes of the institute were as follows:

1. To undertake a basic research program directed toward the causes of mental disease and the development of procedures leading to the prevention and cure
2. To hold a series of teaching institutes on different aspects of the research [in order to] coordinate programs
3. To improve the teaching of residents and medical students with particular emphasis on the development of interest in and understanding of mental

health problems and to stimulate interest in research among residents and medical students

4. To establish an advisory and consultation group which would aid other units in the State of Michigan having to do with research in mental health problems[102]

According to a summary of findings after the first five years, a total of seventy-one projects were carried out, including biochemical and neuromorphological studies at the cell and organ levels; physiological and neurophysiological studies at the organ and individual level; psychological studies at the individual and group level; psychopharmacological studies; social-science studies based on library research; and formal models and cross-level studies. Most of the cross-level research focused on studies of stress and information input overload at the various levels of organization. Considerable research was done on psychopharmaceuticals under Gerard's supervision, primarily meprobamate (Miltown), along with minor studies on the effects of psilocybin and LSD. As coordinator of the systems sciences, Rapoport supervised research in such areas as statistics and computers, heuristic models of learning, mathematical biology, mathematics of social interaction, mathematical linguistics, nets and biophysics, econometrics, cybernetics, and feedback. Other research projects at MHRI included development and standardization of electronic intelligence tests to improve the diagnosis of mental illness, research on the physiological basis of memory, human information processing, unconscious processes and learning, thyroid disease, game theory, and conflict resolution. All of these projects reflected a common interest in models of information processing as an integrative concept capable of linking such fields as endocrinology, neurology, and psychiatry.[103]

The first issue of *Behavioral Science* was published in January 1956, with Miller as editor-in-chief and members of the Chicago, Michigan, and CASBS communities on the original board of editors. Within a year, the circulation was around three thousand. In his editorial for the first issue, Miller describes the journal as "dedicated to the development of broad theories of behavior and their empirical testing," reflecting a shift in emphasis from pure empiricism toward systematization of observations, based on an understanding of the structural and behavioral properties of systems in general. He notes that the journal was unique in soliciting contributions from the humanities, the social sciences, and the biological, medical, and physical sciences. In articulating the aim of behavioral science as identifying and clarifying general principles as well as particular differences, Miller asks, "Can the scientific method solve the larger, more pervasive questions about man as well as the smaller more particular ones? Is the tool with which man has won his victories over the physical world applicable to uncovering the laws which govern man's conduct, the deepest causes of our strife and our harmony?" Among the problems he hoped behavioral science would help to address, Miller mentions social inequality, industrial strife, marital disharmony, juvenile delinquency, mental illness, and war.[104]

The theory group continued to meet on a weekly basis. Summarizing the results of their collaboration in 1956, Gerard went through the entire collection of minutes, abstracting fifty pages of statements. Although the system concept provided an integrating theme, he found a considerable divergence in perspectives: "My only strong conviction after this exercise is that relatively few major issues have come up many times, that individually nearly everyone has shifted his position to and fro on most of them, that collectively the group has widened and narrowed its philosophic base and its working definitions of particular things, and that no real decisions on any of these points have been reached."[105]

As a means of bringing the diversity of views together, the group proposed a joint book on behavioral theory. Each individual would be responsible for a separate chapter, using Gerard's model of the three essential aspects of structure, function, and development, at each of the different levels of organization. Part 1 was to be a summary of the evolution of the behavioral sciences. Part 2, tentatively entitled "Man's Ways to Knowledge," would explore "modes of scientific and intuitive cognition and methods of validation, including conceptual models and functioning of the brain of the observer or integrator." It was to include discussion of such topics as "entities and relations; reductionism and holism; problems of interdisciplinary, multiperson investigation and integration; and norms, values, conflict resolution, and goals. Part 3, "A Conceptual Framework for the General Theory of Living Systems," was to elaborate Gerard's scheme: "being" (structure and organization theory); "behaving" (function of systems); and "becoming" (including genetics, growth, and history). Part 4, "Method and the Conceptual Framework of Mathematics," most of which was to be written by Rapoport, would address the role of mathematical models and other applications of mathematics including information theory, cybernetics, game theory, and computer simulation. Part 5 was to address other conceptual syntheses as well as the relationship between the new science of behavior and traditional approaches in humanities and the social sciences. The last part, to be written by Miller, would address applications and research strategies. While the book was never completed, the collaborative work of the theory group laid the groundwork for Miller's synthesis, published in 1978 as *Living Systems*.[106]

In November 1957, at the request of Vice President Richard Nixon, a national committee was formed, under the auspices of the National Academy of Sciences (NAS), with Miller as chairman, to help ensure that "the national interest would be adequately served by the development and application of the sciences of man." Miller writes that Nixon was worried that the United States was lagging behind the Soviet Union in the development of the behavioral sciences, just as it was in space science. The National Research Council (NRC) met at the Rockefeller Institute to discuss the role of behavioral science in relation to both the academy and the government. Those in attendance included Miller, Gerard, Donald Marquis, Neal Miller (associated with the Yale Institute), Clyde Kluckhohn (who had been a fellow at CASBS with the others), Herbert Simon, Jacob Marschak, Robert Merton, and Ralph Tyler. The committee issued a report entitled "National Support for the Behavioral Sciences" in February 1958, leading eventually to the establishment of a Behavioral Science Committee in the NAS.[107]

In the 1960 *MHRI Bulletin,* Miller suggests that the behavioral sciences are applicable in such fields as "advertising, business administration, education, government, human engineering, labor relations, law, medicine, military science, operations research, personnel selection, public relations and many other areas of human endeavor," echoing findings of the NAS-NRC committee: "The industrial or military organization of the future will require highly selected, thoroughly trained, and technically skilled men who most often must operate as members of closely knit teams in conjunction with extraordinarily complex machines." Further, the report concluded, "The role of man in the last half of this century will increasingly be that of an information processor and decision maker." Although decision processes had been the focus of much research during the 1950s, further work would need to be done, particularly in connection with "the conditions of efficient selection or training of individuals for decision making." In addition, the report emphasized the importance of understanding group functioning, since "modern techniques of cooperation in industry, science, and warfare emphasize a greater reliance upon small groups of men functioning semi-autonomously and integrated into larger operations only through complex and sometimes vulnerable communication systems." President Dwight Eisenhower appointed a delegation of behavioral scientists to visit the USSR, including Miller as chair, along with Gerard and Rapoport. The trip was postponed until May 1961, when a joint meeting of American and Soviet behavioral scientists was hosted by the Soviet Academy of Pedagogical Sciences.[108]

Although MHRI was primarily oriented toward biological and psychological research, there were strong institutional ties with parallel developments in systems engineering and management. Both Gerard and Miller were associated with the Adaptive Systems Committee of the University of Michigan's Institute of Science and Technology. Merrill Flood, a member of the MHRI staff, was also a member of The Institute of Management Sciences and the Operations Research Society of America. In collaboration with Rapoport, he arranged seminars with the operations research group from the Case Institute of Technology, which was established by Russell Ackoff, one of the early theoreticians in the operations research field. William Horvath, also a member of the MHRI staff, was an associate editor of the journal *Operations Research*. As an effort to ground such connections, Miller's living systems theory is by far the most ambitious attempt to synthesize an enormous range of work in the almost impossibly general field of systems research.[109]

Living Systems Theory

Miller's work on living systems represents the most systematic and thorough attempt to articulate functional similarities or isomorphic relationships in systems at different levels of organization. At the same time, it illustrates some of the problems with such an undertaking, fueling much of the criticism that has been directed at GST. Nevertheless, it provides a useful framework and possible directions for further interdisciplinary inquiry. As Miller defines it, living systems theory (LST) is "a conceptual system that offers a way of thinking about all the diverse kinds of living things, a set of integrative concepts for the many disciplines that deal with them, and a practical approach to studying and working with them."[110]

According to Miller, cybernetics and GST were integrated into a single theory, although cybernetics was originally rooted in a mechanical metaphor, while GST was based on an organic metaphor. In the cybernetic model, "organisms are viewed as a special class of machines that operate on engineering principles, particularly control by negative feedback." In contrast, GST is "an integrated view of nature that regards the universe as a concrete system composed of a hierarchy of levels of different types of smaller systems." Incorporating insights from both perspectives, Miller describes living systems as "open, self-organizing systems," with "the ability to maintain, for a significant period, a steady state in which the entropy . . . within the system is significantly lower than in its nonliving surroundings." This is achieved by taking in matter that is low in entropy (and thus high in information) and returning outputs of greater entropy (and correspondingly lower information content) to the environment.[111]

The relationship between matter-energy and information provides a central organizing feature of his system. He notes, with reference to Plato and Aristotle, that every entity is a union of form and matter, and that information can thus be seen as the presence of form, of pattern, and of organization. Further, he suggests that information theory provided the mathematics for measuring form, pointing out the formal similarity between information and negative entropy. In discussing the value of the living-systems approach to psychology, he argues that there is a need for unifying concepts to overcome the fragmentation that exists, particularly between the scientific and humanistic approaches to the field. However, one of the more controversial aspects of his approach is his emphasis on the importance of using the CGS system of measurement in describing and quantifying psychological phenomena. Less controversial is his concern with looking at living systems in the context of the larger systems of which they are parts, although the nature of the relationship between part and whole remains problematic.[112]

Living systems theory is essentially a taxonomy of subsystems that Miller identifies in connection with the inputs, throughputs, and outputs of matter-energy and information in open systems. In fact, Miller likens his theoretical framework to Mendeleyev's periodic table of the elements. He first published his scheme of subsystems in a series of articles in *Behavioral Science,* citing Rudolf Virchow (1862) in support of his conception of subsystems in biological organisms:

> Scientific investigation reveals the individual to be composed of an array of systems; one attends to sensations, another to movements, others to the intake of nourishment and air, some support the parts and others bind them together. Every one of these systems comprises a certain number of special organs; every organ includes a number of tissues, and every tissue is in the end composed of cell regions and cells.[113]

Miller begins with Gerard's seven levels of organization—the cell, organ, organism, group, organization, society, and supranational system. In attempting to categorize parallel structural, functional, and developmental aspects of living systems at each level, he identifies nineteen (later twenty) subsystems, which he divides on the basis of whether they process matter-energy, information, or both. Matter-energy processes relate to the metabolic processes of the system, while information processes deal with coordination, guidance, and control. Table 7.1 provides an overview of his taxomony.

The subsystems that process both matter-energy and information are the reproducer and the boundary. The concept of the boundary as an essential function in the maintenance of a system's integrity was first articulated in conversations at CASBS. As Miller describes it, the boundary of a system acts as a selective filter, maintaining higher or lower concentrations inside the system than in the environment and making it possible for the system to maintain a lower entropy than its surroundings. However, the concept becomes increasingly problematic at higher levels of organization.[114]

The subsystems that process matter-energy deal primarily with the input, output, and internal distribution and storage of matter-energy. Those that process information deal similarly with the input, output, distribution, storage, and encoding and decoding of information. The most interesting and controversial of these is the "decider," which Miller identifies as the "executive subsystem," responsible for analyzing all of the informational inputs in order to "form the intentions of the system and send out signals that control and coordinate the whole system." The nature of this process at higher levels of organization becomes the focus of most critical concern. In his review of *Living Systems,* Alfred Kuhn argues that ecosystems and society as a whole are uncontrolled suprasystems made up of controlled subsystems. In response to Kuhn's claim that such systems have no decider, Miller claims instead that the decider is dispersed.[115]

The difference between these two positions highlights their respective conceptions of decisionmaking; I find the notion of a dispersed decider particularly intriguing. Kuhn suggests that it "muddies social theory to use decision in any situation except those where decision theory is applicable (with at least intuitive weighing of costs and benefits), or where there is some agreement by participants about the outcome of jointly made decisions." For Miller, the decider function is concerned with the determination of outcome and is essential to goal-directedness. He acknowledges significant variation in the degree of centralization or decentralization in the decision processes of systems at various levels, but argues that there is no such thing as an uncontrolled system. In his view, the concept of system implies control; if something is uncontrolled, it is not a system.[116]

Miller points out that ecosystems represent an "exquisitely controlled balance of nature"; even though there is no centralized decisionmaking function, "there is nonetheless a channel and net which stretches through the system, and information is conveyed from plants to animals and among animal species, controlling their behavior." For Kuhn, the concept of decision implies conscious planning and is not

Table 7.1. The Twenty Critical Subsystems of a Living System

Subsystems that process both matter-energy and information	
1. Reproducer: carries out instructions in the genetic information or charter of a system and mobilizes matter, energy, and information to produce one or more similar systems.	
2. Boundary: holds together the components of the system, protects them from environmental stresses, and excludes or permits entry to various sorts of matter-energy and information.	
Subsystems that process matter-energy	*Subsystems that process information*
1. Ingestor: brings matter-energy across the system boundary from the environment.	1. Input transducer: brings markers bearing information into the system, changing them to other matter-energy forms suitable for transmission within it.
2. Distributor: carries inputs from outside the system or outputs from its subsystems around the system to each component.	2. Internal transducer: receives, from subsystems or components within the system, markers bearing information about significant alterations in those subsystems or components, changing them to other transmissible matter-energy forms.
3. Converter: changes inputs into forms more useful for internal system processes.	3. Channel and net: single route or multiple connected routes in physical space, over which markers bearing information are transmitted to all parts of the system.
4. Producer: coordinates matter-energy inputs and outputs from converter to synthesize materials for growth, repair, or the provision of energy.	4. Timer: transmits information about time-related states of the environment or of components to the decider, coordinating system processes in time.
5. Matter-energy storage: stores, retains, and retrieves matter-energy at some location.	5. Decoder: alters the code of information input into a "private" code used internally.
6. Extruder: transmits matter-energy out of the system in form of products or waste.	6. Associator: carries out first stage of learning process, forming associations among items of information in the system.
7. Motor: moves the system or parts of it.	7. Memory: carries out second stage of learning process, storing and retrieving information in the system.
8. Supporter: maintains the proper spatial relationships among the components of the system.	8. Decider: receives information inputs from all other subsystems, transmits them to information outputs for guidance, coordination, and control of the system.
	9. Encoder: alters the code of information from "private" to "public" code that can be interpreted by systems in its environment.
	10. Output transducer: puts out markers bearing information from the system, in matter-energy forms transmissible in the system's environment.

Source: Condensed from a similar table in Miller, *Living Systems,* p. xix.

applicable in situations that seem to be determined by random forces. For Miller, the decider includes "any process which cuts down the number of options between input and output, or the number of statistical degrees of freedom," and, surprisingly, "does not necessarily require feedbacks or 'monitored, controlled states.'"

His notion of a dispersed decider invites a reconceptualization of the meaning of control, which is generally understood in top-down, coercive, power-over kinds of terms. In conjunction with his attribution of goal-directedness to every system, Miller raises the possibility of a self-organizing synergistic type of control (reflected in Lovelock's Gaia hypothesis, for example), although his personal biases tend more toward the former model.[117]

Miller relates the decider function to the allocation of power, both within a particular system and between systems at the same and different levels, and defines power as control, or "the ability of one 'master' system to influence in a specific direction the decision of a 'slave' system at the same or another level." Further, the system with access to the most information is "the one most likely to exercise power over or elicit compliance of other systems in its environment." Miller suggests that systems at each level have a degree of autonomy, at the same time that they are controlled, to some degree, by levels above and below. However, even this relative autonomy is missing in other formulations: "A system is adjusted to its suprasystem only if it has an internal purpose or external goal which is consistent with the norm established by the suprasystem." At the same time, he acknowledges that "a system cannot survive unless it makes decisions that maintain the functions of all its subsystems."[118]

There are similar contradictions in Miller's discussion of centralization in the decisionmaking process. Echoing Spencer, he describes highly centralized processes as integrated and more decentralized processes as segregated. In centralized systems conflict is minimized, while "segregation increases conflict among subsystems or components of a system, and a higher proportion of adjustment processes must therefore be devoted to resolving such conflicts, which means they cannot be devoted to advancing the goals of the system as a whole." In the same article, however, he writes that decentralization of decisionmaking tends to increase the speed and accuracy of decisions, thereby reducing local strains. Further, as long as adequate information is available to the segregated components of the decider, "the more decentralized the decider of a system is, the better will be the co-action of its subsystems."[119]

In contrast, his discussion of evolution implies that all systems tend toward greater centralization. Since natural selection fosters the survival of the best adjusted or most stable systems, the evolution of social systems tends toward increasing social integration, with increasing centralized control by the system's decider. Echoing Parsons, he writes: "The growth of social harmony and peaceful relationships in an integrated society . . . implies the growth of mutual adjustment and adaptation between the members of the society." Further, in reference to Cannon, he suggests that the integration of parts into larger systems involves "social organization, social control, and a lessening of the independence of the individual members." Still, the increase in social control is balanced with the necessity of providing for individual needs: "The social organism, like the bodily organism, cannot be vigorous and efficient unless its elements are assured the essential minimal conditions for healthful life and activity."[120]

This organismic model, central to both Gerard's and Miller's views, was the basis of Boulding's distinction between his conception of GST and that of Miller, although he saw the two approaches as complementary. Boulding describes Miller's approach as essentially physiological, with each level maintaining the same basic organismic structure. He suggests that the LST model is too complex at lower levels and not complex enough at higher levels. In contrast to this physiological model, Boulding posits his evolutionary model of ecological interaction under constantly changing parameters. While Miller's system is rooted in the organism as its primary metaphor, Boulding echoes Kuhn's appeal to the ecosystem model. He doubts whether Miller's nineteen subsystems could all be found in an ecosystem, and argues that it is ecosystems that guide evolution. Society, he says, is not a physiological system but "an ecosystem of interacting biological and human artifacts." Further, he writes that Miller's discussion of evolution is limited because "a physiological system is not really evolutionary."[121]

Boulding's perspective is echoed by Rapoport, who writes, "Miller's conceptualization of system-maintaining functions is too tightly bound up with the functions of individual biological organisms to provide a basis for a general theory of living systems, if socially organized aggregates are to be included among these." Kuhn suggests that Miller's model works best for the biological levels of cell, organ, and organism as well as formal social organizations such as government, while a more "uncontrolled" model would be better for the group, society, and the supranational system. While government is the sole decider at the level of society in Miller's system, Kuhn sees it as only one among many. In addition, Rapoport, Kuhn, and Boulding all emphasize the importance of meaning and values in the social levels of organization. Rapoport writes that "ideational notions" cannot be adequately described in terms of information processing, particularly within an organismic framework. Rapoport was also skeptical of Miller's insistence on using the CGS system in describing all aspects of living systems. Miller himself notes, in *Living Systems,* that "the fit between the conceptual system and the empirical findings reported in this book appears poorest at the highest two or three levels," although he attributed this to a lack of sufficient data.[122]

In Miller's response to his reviewers, he writes that he is puzzled that Boulding "seems to ignore the explicit evolutionary aspect of [his] theory," rejecting Boulding's contention that physiological systems are not evolutionary and citing Parsons's comment, in *his* review of *Living Systems,* that Miller's framework is "clearly evolutionary," raising questions of definition. Although Miller concedes that each level contains emergent properties that are not found at lower levels, the basic structure of processes remains the same at every level, evoking Boulding's comment that his taxonomy is one of structure rather than of processes. Miller again disagrees, pointing out, with reference to Whitehead, that "life is fundamentally process" and that his system is an attempt to articulate the relationship between structure and process at the various levels: "Systems at each higher level have a greater number and more different kinds of components as well as more complicated relationships among components," resulting in emergent properties.

Still, his model tends to emphasize the continuity between levels. In the conclusion of *Living Systems,* he writes, "All nature is a continuum. The endless complexity of life is organized into patterns which repeat themselves at each level of system."[123]

CONCLUDING REFLECTIONS

In his introduction to *Living Systems,* Miller writes that there is a "tremendous variation in systems theories that have developed in different fields." Rapoport suggests that GST is not a "theory" in the traditional sense, since its purpose is "to prepare definitions and hence classifications of systems that are likely to generate fruitful theories." Boulding echoes this view in his review of *Living Systems,* commenting that the founders of SGSR defined a general system as "any theoretical system of interest to more than one discipline." Thus, he suggests that there should be many general systems, "not so much because it is beyond the capacity of the human mind to produce a single one, but because there is more than one general system in the real world." Despite the profound differences in their respective approaches, Boulding considered them to be complementary.[124]

There are, however, some critical distinctions in the social implications of the various approaches. One of the primary issues dividing the organismic approach of Gerard and Miller from the organismic approach as conceived by Bertalanffy, the ecological approach of Boulding, and the mathematical/semantic approach of Rapoport has to do with the relative degree of continuity between different levels of living systems. While Bertalanffy objected to the reductionism inherent in the mechanistic approach to the study of biological systems, the cybernetic approach embraced in the work of Gerard, Miller, and, to some extent, Rapoport was explicitly rooted in a mechanical metaphor, often the focus of critiques of cybernetics. Yet the concept of feedback, central to the cybernetic model, can be used to emphasize issues of control, or, alternatively, to highlight the enigmas of circular causality. While the first orientation tends to reinforce predominantly deterministic models of behavior, the latter underscores the complex and paradoxical nature of the relationship between part and whole, granting a degree of relative autonomy to each level of organization.

The most important discontinuity in the relationship between biological and psychosocial dimensions of human behavior has to do with the role of values and symbolic communication. The disparity between these two perspectives, as well as their potential complementarity, is reflected in the following passage from Rapoport's foreword to Walter Buckley's *Modern Systems Research for the Behavioral Scientist: A Sourcebook,* a comprehensive collection of articles related to the evolution of systems thinking in the social sciences:

> Behavioral scientists can be roughly divided into two groups: those who aspire to the scientific status of physical scientists and, in consequence, tend to select research problems that yield to the analytic method; and those who are moved by a need to "understand man." The former stand in danger of trivializing the study of man and, what is often

> worse, of placing their expertise at the service of groups having power to manipulate man for their own purposes. The latter stand in danger of obscuring the study of man in free-wheeling speculations without sufficient anchorage in facts or testable hypotheses. Both of these dangers have been aggravated by the seductive potential of the new system concepts. . . . Not the least of the dangers associated with these sanguine extrapolations is that the intellectually responsible behavioral scientist, upon discovering the sterility of such speculations, will dismiss the new ideas as altogether irrelevant. This, I think, would be a mistake. The ideas of the system approach can be a rich source of inspiration in the advancement of behavioral science, but only if the actual content and scope of these ideas are clearly understood. The system approach to the study of man can be appreciated as an effort to restore meaning (in terms of intuitively grasped understanding of wholes) while adhering to the principles of disciplined generalizations and rigorous deduction. It is, in short, an attempt to make the study of man both scientific and meaningful.[125]

Along these lines, Rapoport and Bertalanffy were closer in spirit, although Bertalanffy was less explicitly political in his interpretation of the social and psychological implications of his systems conception of humanity. Nevertheless, like Rapoport and Boulding, his criticism of military policies during the Vietnam War reflects his understanding of the implications of GST. He suggests that a general-systems approach would have included a consideration of such nonmilitary factors as Vietnamese history, culture, and nationalism, as well as the morale of American forces in such a politically and ethically ambiguous war, and it would have seriously questioned the American commitment in Vietnam. According to Bertalanffy's conception of GST, the process of boundary definition requires a consideration of all relevant factors. At the level of social and political systems, this entails a critical evaluation of the system's goals in relation to the values of its individual members.[126]

Here again, the "decider" function is key—the nature of the decisionmaking process and the way in which the system's goals are determined. Gerard, more than any of the others, views social integration in terms of highly centralized decision-making processes, where the interests of the individual are increasingly subordinated to the interests of the whole. Of course, he also assumes that individual interests are basically harmonious with the interests of the whole, but he fails to address the potential conflict between individual interests and how such conflicts are to be resolved. Although his writings are contradictory on this point, Miller at least entertains the possibility of a decentralized decisionmaking process, which he nevertheless views in fairly deterministic terms, and his conception of values in terms of the elimination of strains is somewhat reductionist. Rapoport, on the other hand, is more sensitive to the potential for abuse of power and highlights the subjective, symbolic dimension of values as an essential aspect of the general-systems approach. This relationship between the role of values and the nature of the decisionmaking process is central to Boulding's work and will be elaborated further in the following chapter.

It might be argued that the general-systems community has never really managed to overcome the division between C. P. Snow's two cultures and that the attempt to marry science and values is doomed from the start. On the other hand, the conversation between scholars across such widely diverse orientations that was fostered by the general-systems community is valuable in itself. Ultimately, conversation and dialogue become a central feature of Boulding's work and of many who have followed in his footsteps. Even more important are the conditions of interaction that determine the quality of the conversation. Far too often these days, dialogue between scientists and humanists (not to mention political opponents) is articulated in hostile and antagonistic terms, as for example in the "science wars." Those who attempt to build common ground are often accused of complicity. And yet, it is in conversation between people that meaning is created and connections are made; shared understanding emerges, values are articulated, and mutually acceptable goals can be agreed upon. The question that remains, of course, is who gets to participate in the conversation.

Although I could never agree with Miller that everything of significance can be expressed in terms of the CGS system, his work has a lot to contribute to the study of complex systems. The mathematics of quantification and measurement is clearly limited when it comes to understanding human systems. On the other hand, the mathematics of pattern and relationship, reflected in chaos theory, fractals, and self-organizing systems, provides a richer and more meaningful approach to modeling the ever-changing nature of reality. Despite its somewhat reductionist orientation, Miller's work provides a provocative framework for exploring similar processes in different types of systems. Most significantly, it highlights the role of information in maintaining the antientropic nature of evolution and of life. Given the way in which humanity is rapidly destroying the information stored over billions of years of evolution, hastening the march toward terminal entropy mandated by the infamous second law of thermodynamics, it would behoove us to consider what might serve as a social equivalent of negative entropy. It is often said that money is a form of information, although it seems to function more like positive rather than negative entropy, increasing the disorder of the system as a whole. In addressing this conundrum, Boulding introduces his concept of the "integrative function" as an essential complement to the exchange function of the marketplace and the control function of the political system, which offers some promising insights about how to restore the integrity of both the social order and the ecological context within which it must learn to function in a more sustainable fashion if it hopes to endure.

NOTES

1. James Grier Miller and Jessie L. Miller, "Preface," in revised edition of *Living Systems* (Boulder: University Press of Colorado, 1995), pp. xiii–xiv.

2. James Grier Miller, "Introduction," *Symposium: Profits and Problems of Homeostatic Models in the Behavioral Sciences* (Chicago Behavioral Science Publications, No. 1,

Ann Arbor, MI: Braun-Brumfield, Inc., 1953), p. 1. In addition to Miller, the other members of the committee included Ralph Gerard, Anatol Rapoport, David Easton, and Donald Campbell. Pogo is quoted again in Miller's magnum opus, *Living Systems* (New York: McGraw Hill, 1978), p. xvii.

3. See Letter from Bertalanffy to Gerard, Nov. 10, 1953 (in Ralph Waldo Gerard Collection, Department of Special Collections, University of California at Irvine, hereafter referred to as RWG, Box 11), regarding the invitation to participate in Grinker's study group. See also Roy Grinker, *Toward a Unified Theory of Human Behavior* (New York: Basic Books, 1956).

4. Kenneth Boulding, "Systems Profile: Some Origins," *Systems Research* 4:4 (1987): 287; Cynthia Kerman, *Creative Tension: The Life and Thought of Kenneth Boulding* (Ann Arbor: University of Michigan Press, 1974), p. 46.

5. See Letter from Gerard to S. I. Hayakawa, March 1, 1972. Gerard writes that his own position was closer to Hayakawa's than to Rapoport's (RWG, Box 43).

6. Ralph Gerard, Letter in support of Bertalanffy's application, Dec. 5, 1953 (RWG, Box 11); Gregg Mitman, *The State of Nature: Ecology, Community, and American Social Thought, 1900–1950* (Chicago: University of Chicago Press, 1992), pp. 162–163; Robert Lilienfeld, *The Rise of Systems Theory: An Ideological Analysis* (New York: Wiley, 1978).

7. See Ben Libet, "R. W. Gerard," *Journal of Neurophysiology* (July 1974): 828–829, for comments on Gerard's impact in neurophysiology. See Mitman, *The State of Nature,* for a discussion of Gerard's involvement with the development of ecological thought at Chicago; and Steve J. Heims, *Constructing a Social Science for Postwar America: The Cybernetics Group, 1946–1953* (Cambridge, MA: MIT Press, 1991), on Gerard's participation in the cybernetics conferences. Gerard uses the word "org" as more or less equivalent to "living system."

8. Ralph Gerard, "The Minute Experiment and the Large Picture" (RWG, Box 98), pp. 15, 21; James Grier Miller, "Closing Comments," in Frosty Gerard, "Ralph Waldo Gerard," *Behavioral Science* 20:1 (Jan. 1975): 6. Gerard compiled extensive notes on Spencer in his early years at Chicago regarding the similarities and differences between organisms and societies (RWG, Box 4).

9. Anatol Rapoport, "The Systemic Approach in Psychology," *Psikhologicheskyi Zhurval* 15:3 (1994): 1 (references to this article are from typed manuscript, pp. 1–19); Ralph Gerard, "Statement of Possible Activities at the Center," July 7, 1954 (CASBS Archives), p. 1; Libet, "R. W. Gerard," p. 828; Roxanne-Louise Nilan, "The Ralph Waldo Gerard Collection," University of California at Irvine, Special Collections (guide to collection).

10. Nilan, "The Gerard Collection"; Frosty Gerard, "Ralph Waldo Gerard," pp. 3–5.

11. Libet, "R. W. Gerard," p. 829; Frosty Gerard, p. 3, Miller, "Closing Comments," p. 6, and Anatol Rapoport, "Additional Remarks," p. 8, in Frosty Gerard, "Ralph Waldo Gerard"; Daniel G. Aldrich Jr., "Remarks at Gerard Memorial Convocation, 3/7/74" (RWG, Box 98), p. 2; A. M. Potts, "Comments at Memorial Service for Gerard at the University of Chicago, May 3, 1974" (RWG, Box 98), p. 2; Gerard quotes from "Notes for Dartmouth Convocation," 1960 (RWG, Box 25), p. 5; and "Top Level War Plans," 1972 (RWG, Box 98), p. 34.

12. Gerard, "Top Level War Plans," pp. 15–16, 21; Libet, "R. W. Gerard," p. 828; Charles Moritz, ed., *Current Biography Yearbook* (New York: H. W. Wilson Co., 1965), p. 161.

13. Gerard, "Top Level War Plans," pp. 23–26, 28–29.

14. Gerard, "The Minute Experiment," pp. 2, 5; "Top Level War Plans," p. 33; Libet, "R. W. Gerard," p. 829; Frosty Gerard, "Ralph Waldo Gerard," p. 1. Gerard did his graduate work with Anton Carlson and Ralph Lillie (Mitman, *The State of Nature,* p. 162).

15. Gerard, "The Minute Experiment," pp. 5, 15; Libet, "R. W. Gerard," p. 829; Frosty Gerard, "Ralph Waldo Gerard," p. 2. Gerard was promoted to associate professor in 1929 and full professor in 1942.

16. Gerard, "The Minute Experiment," p. 28; Libet, "R. W. Gerard," p. 829. See discussion of EDUNET in section on Miller's work.

17. Nilan, "The Gerard Collection," p. 1; Frosty Gerard, "Ralph Waldo Gerard," p. 4.

18. Gerard, "The Minute Experiment," p. 23; Ralph Gerard, *Unresting Cells* (New York: Harper, 1940); "Information Processing in the Nervous System," (RWG, Box 11); Frosty Gerard, "Ralph Waldo Gerard," p. 3.

19. Gerard, "The Minute Experiment," p. 28; Moritz, ed., *Current Biography,* p. 22.

20. Frosty Gerard, "Ralph Waldo Gerard, p. 4; Anatol Rapoport, *General System Theory: Essential Concepts and Applications* (Cambridge, MA: Abacus Press, 1986), p. 21.

21. Ralph Gerard, *Concepts of Biology* (Washington, DC: National Academy of Science–National Research Council, Publication 560, 1958), pp. 93, 99.

22. Gerard, "Top Level War Plans," p. 28; Ralph Gerard, "Organism, Society, and Science," *Scientific Monthly* 50 (April–June, 1940): 12. Gerard acknowledges that one "cannot concede that the organism is merely a model for the epiorganism any more than is the cell for the organism. If a society is an org at all, . . . it is related to the organism of which it is composed, and in turn to their cells, as an org of order N+1 is to an org of order N." Nevertheless, while most scholars tended to focus on the differences between orgs of different order, he sought to discover common principles.

23. Walter Cannon, *The Wisdom of the Body* (New York: Norton, 1932); Mitman, *The State of Nature,* pp. 146, 151. See *Biological Symposia* 8 (1942), for a collection of papers presented at the symposium, especially Gerard, "Higher Levels of Integration," pp. 67–87. Mitman offers an excellent discussion of organismic models in the Chicago school of ecology, which focused on the transfer of matter and energy in communities of organisms (p. 140). With the addition of information transfer, this orientation parallels Miller's and Gerard's conception of GST.

24. Gerard, "Organism, Society, and Science," p. 17; Mitman, *The State of Nature,* pp. 151, 157–160. See also Alfred Emerson, "The Biological Basis of Social Cooperation," *Illinois Academy of Science Transactions* 39 (1946): 9–18. C. M. Child's work on gradients was central to Gerard's work. Like Boulding, Allee was a Quaker; unlike the others he saw cooperation as a primary goal and did not support the conclusion that cooperation was dependent upon gradients of control.

25. Ralph Gerard, "The Rights of Man: A Biological Approach," a memo to the UN Committee on the Rights of Man, dated Spring 1947 (RWG, Box 47), p. 2; Mitman, *The State of Nature,* pp. 159–160. Gerard presented his ideas along these lines in Boulding's seminar on conflict resolution at the University of Michigan, the year after they met at CASBS.

26. Ralph Gerard, "The Organismic View of Society," in *Symposium,* p. 13; "The Rights of Man," p. 7. Gerard writes: "Biology . . . has much to say of the forces operating in such communities of individuals, of the freedoms, duties, controls that must be present, and of regular trends in these over the enormous span of organic evolution" ("Rights of Man," p. 1). In "Organism, Society, and Science," he writes, "To say that the org is fully controlled by its units is tantamount to denying organization, for the essence of an org is that the units in it act differently from solitary ones by virtue of their incorporation in the system, . . . [which] can be modified by the environment acting upon it at either level" (p. 3). See also Mitman, *The State of Nature,* pp. 165, 184.

27. Ralph Gerard, "A Biological Basis for Ethics," *Philosophy of Science* 9:1 (Jan. 1942): 115, 117–118; "Organism, Society, and Science," p. 26.

28. Gerard, "The Rights of Man," p. 7; "Organism, Society, and Science," p. 26; Mitman, *The State of Nature,* pp. 164, 167.

29. Gerard, "Organism, Society, and Science," pp. 17–21 (long quote pp. 19–20); "Biological Basis for Ethics," p. 119.

30. Gerard, "Organism, Society, and Science," pp. 18, 20, 25.

31. Gerard, "Biological Basis for Ethics," pp. 92–97, 103; "Organism, Society, and Science," pp. 1, 22–25; "Rights of Man," p. 1. Gerard is writing in response to Mortimer Adler's critique of science. He compares the natural scientist to the "exteroceptors," which inform the organism of its surroundings, and the social scientist to the interoceptors, which act via the autonomic nervous system to "regulate and coordinate the parts of the organism" ("Organism, Society, and Science," p. 22).

32. Ralph Gerard, "Moral Implications of Scientific Research" (RWG, Box 4), pp. 1–2; Bulletin of the Mental Health Research Institute, 1957. Longer quote from "Notes for Dartmouth Convocation," pp. 1–2, 5.

33. D. H. Loomer, "Liberalism and Coercion," p. 3 (Gerard's notes do not give exact citation).

34. Gerard, "Higher Levels of Integration," p. 85.

35. Rapoport was kind enough to share with me initial drafts of the English translation of his autobiography, *Certainties and Doubts,* originally published in German as *Gewissheiten und Zweifel* (Darmstadt: Verlag Darmstädter Blätter, 1994). Since I received each chapter as a separate document, the chapters are each numbered separately. The quote is taken from chapter 1, p. 1. See also Rapoport's summary of his work at the center (n.d.), from CASBS archives, regarding the mathematics refresher course.

36. Rapoport, "Additional Remarks," p. 7; also Rapoport, "The Systemic Approach in Psychology," pp. 3–16.

37. Rapoport, *Certainties and Doubts,* ch. 2, p. 10; ch. 8, pp. 1–3; ch. 12, p. 3; personal interview, June 1994.

38. Kenneth Boulding, Letter to Eli Shapiro, School of Industrial Management, MIT, Mar. 1, 1955, Kenneth Boulding Collection, Bentley Historical Library, University of Michigan at Ann Arbor (hereafter, KEB/MI, Box 5); "Bulletin of the Mental Health Research Institute," 1960, p. 37.

39. Rapoport, *Certainties and Doubts,* ch. 1, pp. 1, 3; ch. 2, p. 1; ch. 3, pp. 1, 3, 6, 8, 11; ch. 6, p. 6.

40. Ibid., ch. 1, p. 2; ch. 5, pp. 4–7; ch. 6, pp. 1–3, 8; Anatol Rapoport, "Newtonian Physics and Aviation Cadets," *ETC: A Review of General Semantics* 1:3 (1944); S. I. Hayakawa, *Language in Action* (New York: Harcourt, Brace, 1941); Alfred Korzybski, *Science and Sanity* (Lakeville, CT: International Non-Aristotelian Library Pub. Co., 1958).

41. Rapoport, "The Systemic Approach," p. 4; *Certainties and Doubts,* ch. 6, p. 13; ch. 7, pp. 1–2; Rapoport cites an article by Nicholas Rashevsky, "A Problem of Mathematical Biophysics of Interaction of Two or More Individuals Which May Be of Interest in Mathematical Sociology," from the *Bulletin of Mathematical Biophysics,* which was edited by Rashevsky and published by Mathematical Biology, Inc., from 1939 to 1972. See also Rapoport, "Statement," April 21, 1954 (CASBS archives), describing his intended areas of research during his year at CASBS, specifically in applying mathematical methods in fields where they are not yet widely developed; Anatol Rapoport, "Mathematical Theory of Motivation of Interactions of Two Individuals," *Bulletin of Mathematical Biophysics* 9:1: 17–27, 41–61; and Nicholas Rashevsky, *Mathematical Biology of Social Behavior* (Chicago: University of Chicago Press, 1951).

42. Rapoport, *Certainties and Doubts,* ch. 9, pp. 13–14. Rapoport writes that he met with John von Neumann regarding possible sources of support for research in mathematical biology and was shocked to discover that von Neumann advocated a preventive war against the USSR; as a result, he says, his faith in science was somewhat shaken (ch. 1, p. 5). During the 1960s and 1970s the Mental Health Research Institute sponsored an extensive program of peace research, "Correlates of War," based on Richardson's work and led by David Singer (ch. 9, p. 15).

43. Rapoport, *Certainties and Doubts,* ch. 9, pp. 20–22; ch. 10, pp. 1, 4. Rapoport wrote four books between 1970 and his official retirement in 1976, all of which dealt with issues of peace and conflict resolution: *The Big Two: Soviet-American Perceptions of Foreign Policy* (New York: Bobbs-Merrill, 1971); *Conflict in Man-Made Environment* (London: Penguin Books, 1974); *Semantics* (New York: Thomas Crowell, 1975); and *The 2 x 2 Game* (Ann Arbor: University of Michigan Press, 1976).

44. Rapoport, "Statement," pp. 2–3. See, for example, Anatol Rapoport and A. Shimbel, "Statistical Approach to the Theory of the Central Nervous System," *Bulletin of Mathematical Biophysics* 10:1 (1948): 41–55; and Anatol Rapoport, "Cycle Distribution in Random Nets," *Bulletin of Mathematical Biophysics* 10:3 (1948): 145–157. Rapoport became increasingly cognizant of the problems involved in applying the purely technical insights of information theory in broader fields. See his article "The Promise and Pitfalls of Information Theory," in Walter Buckley, ed., *Modern Systems Research for the Behavioral Scientist: A Sourcebook* (Chicago: Aldine, 1968), pp. 137–142.

45. Anatol Rapoport, *General System Theory: Essential Concepts and Applications* (Cambridge, MA: Abacus Press, 1986), pp. 1–5, 28–29; "Systemic Approach," p. 17; "Statement," pp. 1, 3.

46. Rapoport, *General System Theory,* pp. 14–16; "Systemic Approach," p. 18.

47. Rapoport, *General System Theory,* pp. 1; "Statement," p. 3.

48. Rapoport, *General System Theory,* pp. 4–6, 20.

49. Ibid., pp. 11–12. He notes that preserving the identity of the system is not equivalent to the absence of change, but to a preservation of a certain level of constancy amid change (pp. 8, 12).

50. Rapoport, *Semantics; Certainties and Doubts,* ch. 7, pp. 1–2. The arms race was the central focus of the following books: *Fights, Games, and Debates* (Ann Arbor: University of Michigan Press, 1960); *Strategy and Conscience* (New York: Harper, 1964); *The Big Two* (1971); and *The Origins of Violence* (New York: Paragon House, 1989).

51. Rapoport, "Systemic Approach," pp. 6–8, 16, 18.

52. Anatol Rapoport, *Science and the Goals of Man: A Study in Semantic Orientation* (New York: Harper, 1950); *Operational Philosophy* (New York: Harper, 1953); *Certainties and Doubts,* ch. 7, p. 7.

53. Rapoport, *Certainties and Doubts,* ch. 7, p. 8–10; Alfred Korzybski, *Manhood of Humanity* (New York: E. P. Dutton, 1921) and *Science and Sanity*. Rapoport mentions Lenin's tendency to condemn by labeling as an example of confusing verbal maps for reality, describing Cold War rhetoric as an example of language pathology. He and his wife wrote an article on this, "Sanity and the Cold War," that Hayakawa refused to publish. Instead, it was published in *Measure,* the University of Chicago magazine edited by Hutchins (Rapoport, *Certainties and Doubts,* ch. 7, p. 11).

54. Rapoport, *Certainties and Doubts,* ch. 7, p. 6; ch. 9, p. 18; ch. 12, p. 2.

55. Rapoport, "Systemic Approach," pp. 13–14. See also Anatol Rapoport, "The Use and Misuse of Game Theory," *Scientific American* (Dec. 1962): 108–114; "Application of Game Theoretical Concepts in Biology," *Bulletin of Mathematical Biology* 47:2 (1985); *The*

Big Two, pp. 161–192; and Maynard Smith, *Evolution and the Theory of Games* (Cambridge and New York: Cambridge University Press, 1982).

56. Anatol Rapoport and Albert Chammah, *The Prisoner's Dilemma: A Study of Conflict and Cooperation* (Ann Arbor: University of Michigan Press, 1965); Rapoport, *Certainties and Doubts,* ch. 8, pp. 4–5. In collaboration with Howard Raifa, Duncan Luce wrote the first textbook on game theory, *Games and Decisions* (New York: Wiley, 1957). The "Prisoner's Dilemma" inspired many research projects on cooperative behavior; Rapoport estimates that results from two hundred such experiments were published between 1965 and 1971 alone—in William Poundstone, *Prisoner's Dilemma* (New York: Doubleday, 1992), p. 173. Poundstone offers an excellent discussion of game theory and the Cold War, as well as Rapoport's contributions to the field. See also Natalie S. Glance and Bernardo A. Huberman, "The Dynamics of Social Dilemmas," *Scientific American* (March 1994).

57. Rapoport and Chammah, *Prisoner's Dilemma;* Rapoport, *Strategy and Conscience; Fights, Games and Debates; Certainties and Doubts,* ch. 9, pp. 5, 8; ch. 10, p. 4; Poundstone, *Prisoner's Dilemma,* pp. 236–248. Axelrod was a professor at the University of Michigan.

58. Rapoport, *Certainties and Doubts,* ch. 9, pp. 9–10, 12–14. Rapoport points out that *Fights, Games, and Debates* came out the same year as Thomas Schelling's *The Strategy of Conflict,* and was lavishly praised by Schelling, while *Strategy and Conscience* was panned. Rapoport explains that their respective evaluations of the implications of non–zero-sum games for theories of conflict were dramatically different. For Schelling, an appreciation of non–zero-sum games simply extended the available possibilities for compelling the opponent's submission beyond the primary tactic of violence to include negotiation, based on the assumption of at least minimal areas of common interest.

59. Rapoport, *The 2 x 2 Game; Certainties and Doubts,* ch. 10, p. 3.

60. Rapoport, *Conflict in Man-Made Environment,* pp. 7–10.

61. Ibid., pp. 11–12, 15–16, 23–25.

62. Rapoport, *Certainties and Doubts,* ch. 11, pp. 5–7, 15.

63. Ibid., ch. 11, p. 7.

64. Ibid., ch. 11, pp. 7–9.

65. James Grier Miller, "The Scientific and Professional Activities of James Grier Miller," p. 21 (from Miller's Personal Files); *Living Systems,* p. xiv.

66. Miller, "The Scientific and Professional Activities," p. 11, 18.

67. "Remarks by Linda Peeno, M.D., Dedication: James Grier and Jessie Louise Miller Information Technology Center, 3/20/95" (from copy of Dr. Peeno's draft); Miller, *Living Systems.*

68. See Kenneth Boulding, "Universal Physiology," p. 690, and James G. Miller, "Response to the Reviewers of *Living Sytems,*" p. 712, both in "Symposia" (a collection of reviews of *Living Systems*), *Contemporary Sociology* 8:6 (Sept. 1979). Miller himself disagreed with Boulding's characterization of their differences, arguing that he was not a physiologist, but a psychologist, psychiatrist, and philosopher. This issue will be addressed further in the section on living system theory.

69. Rapoport, *Certainties and Doubts,* ch. 8, p. 5; videotaped conversation between Miller and Mead, Systems Science Institute, University of Louisville, 1976 (copy made available by Miller).

70. Personal interview with Miller at the annual conference of the International Society for the Systems Sciences, June 1994.

71. Miller, *Living Systems,* p. xiv.

72. Ibid., p. xiv; "The Scientific and Professional Activities," pp. 1–3; personal interview, June 1994. I have very little information about Miller's early years, although one of the

current members of the MHRI staff, who was a graduate student when Miller was director there, mentioned that Miller had been one of the radio "Whiz Kids" (interview with Sylvan Kornblum at MHRI in June 1994).

73. Miller, "The Scientific and Professional Activities," pp. 2–3; *Living Systems,* pp. xiix–xiv, 1025, 1050. Miller quotes R. L. Schanck, *The Permanent Revolution in Science* (New York: Philosophical Library, 1954), p. xiii, in reference to Gibbs et al.

74. Miller, "The Scientific and Professional Activities," pp. 3–4; personal interview, June 1994; Miller's memoirs presented at ISSS annual conference, July 1996. Miller was elected president of the Division of Clinical Psychology of the APA in 1958–1959.

75. Miller, "The Scientific and Professional Activities," pp. 4–5; *Living Systems,* p. xvi.

76. Miller, "The Scientific and Professional Activities," p. 6; *Living Systems,* p. xv; "Toward a General Theory for the Behavioral Sciences," *The American Psychologist* 10:9 (Sept. 1955): 513–531 (presented at the twenty-fifth anniversary of the University of Chicago Social Science Building, November 1955); quote regarding Congress from p. 513, referring to 1946 debates about whether or not the National Science Foundation should include funding for the social sciences.

77. Miller, "The Scientific and Professional Activities," p. 6; *Living Systems,* pp. xv; "Appendix: Historical Note on the Development of the Center," in KEB/CU, Box 5, pp. 4, 6–7. Ralph Tyler was responsible for bringing Miller to Chicago in 1948 (personal interview, June 1994). Miller writes, "Increasing support and interest in behavioral science has been evidenced by some foundations and industries, following the establishment in Stanford of the Center for Advanced Study in the Behavioral Sciences by the Ford Foundation," in "The First Five Years: A Summary of Activities of the Mental Health Research Institute from Its Founding Through July, 1960," MHRI Fourth Annual Report, 1960 (from MHRI library files), p. 47.

78. Miller, "The Scientific and Professional Activities," pp. 6–7; *Living Systems,* pp. xvi–xviii.

79. Miller, "The Scientific and Professional Activities," pp. 10–11; Medical School Records, in the Bentley Historical Library of the University of Michigan at Ann Arbor (hereafter MED), Box 172.

80. Miller, "The Scientific and Professional Activities," pp. 11–12. MHRI was described as a "beehive" by William Horvath, a member of the MHRI staff during this period (personal interview, June 1994).

81. Miller, "The Scientific and Professional Activities," pp. 14–16; James Grier Miller, "Coping with Administrator's Information Overload," *Journal of Medical Education* 39:11 (Nov. 1964): 47–54; G. Brown, J. Miller, and T. Keenan, eds., *Edunet: Report of the Summer Study on Information Networks* (New York: Wiley, 1967), pp. v, xi. Founding members of EDUCOM included Duke University, the University of Virginia, the State University of New York, Harvard University, University of Pittsburgh, University of Michigan, University of Illinois, and the University of California. See James Grier Miller, "EDUCOM: Interuniversity Communications Council, *Science* 54 (Oct. 28, 1966): 483–488, for his suggestion that educational networks might someday become international.

82. Miller, "The Scientific and Professional Activities," pp. 17–18; *Living Systems*.

83. James Grier Miller, Application to University of Chicago from Committee on Behavioral Science (1954, in RWG, Box 57), pp. 1, 4, 14; "Report of the Ad Hoc Committee on a Proposed Institute for the Behavioral Sciences," January 11, 1952 (RWG, Box 2).

84. First Meeting of Committee on Neural-Mental Problems, 9/29/49; Second Meeting of Committee on Neural-Mental Behavior, 10/13/49; Memo from E. C. Cowell, Central

Administration, 11/9/49; "Meeting of the University Committee on the Mental and Behavioral Sciences," 12/14/49; Memo to Gerard from L. T. Coggeshall, n.d. (all from RWG, Box 2). Also, James Grier Miller, "Toward a General Theory for the Behavioral Sciences," *The American Psychologist* 10:9 (Sept. 1955): 513–514. The initial proposal for the institute was endorsed by the social-science division but rejected by the biological-science division ("Proposal: An Institute for the Behavioral Sciences," 11/16/51, RWG, Box 2).

85. "Report of Ad Hoc Committee"; "Minutes of the fourth meeting of the NAS-NRC Committee on the Behavioral Sciences," summer 1959 (RWG, Box 12), pp. 9–10.

86. Ralph Gerard, "What Is Behavioral Science?" Memorandum to University of Michigan Special Committee on Research in Behavioral Science, Dec. 30, 1955 (RWG, Box 12), pp. 1–4.

87. James Grier Miller, "The Behavioral Sciences," unpublished manuscript, May 1951, p. 2.

88. Ibid., pp. 3, 5, 7.

89. Ibid., pp. 9–13, 20.

90. Ibid., pp. 18, 21–27. Pages 21 through 27 contain a table of twenty-two "Basic Principles of Behavior," along with a corresponding physiological description, behavioral concomitant, subjective concomitant, and physical model for each principle.

91. Ibid., pp. 65–72, 77; also personal interview, June 1994.

92. Miller, "The Behavioral Sciences," pp. 111–114.

93. Ibid., pp. 114–117, 123 (long quote from Gordon and Haigh on p. 116, though no specific reference is given; emphases and ellipsis are Miller's).

94. Miller, "The Scientific and Professional Activities," pp. 7–8; *Symposium: Profits and Problems of Homeostatic Models in the Behavioral Sciences* (Chicago Behavioral Sciences Publications, No. 1, 1953).

95. Miller, "Toward a General Theory," pp. 513–514.

96. Ibid., pp. 514–518, 524–525. See chart p. 524. Processes that he saw as common to both computers and mental function included "sensory input and energy input, decoder, memory, internal communication system, internal motor system, association area, executive/decision-maker/calculator, etc."

97. Rapoport, "Systemic Approach," p. 1; Donald Fiske, "Suggested Problem Areas for the Consideration of the Behavioral Sciences Study Group," Oct. 3, 1952 (RWG, Box 57).

98. Ralph Gerard, "General Behavioral Systems Theory: Minutes and Transcriptions of the Theory Group Meetings," June 30, 1954 (RWG, Box 57), pp. 1, 5.

99. Ibid., pp. 7–8.

100. Ibid., pp. 8–9.

101. Miller, personal interview, June 1994; Rapoport, *Certainties and Doubts,* ch. 8, p. 5; Gerard, "Statement." Gerard notes that he and Rapoport worked on applying the biological notion of evolution to the evolution of language and roles in connections with a workshop on mathematical relationships in biological and social systems. In 1957 Richard Meier took over as secretary-treasurer of SGSR from Bertalanffy, who had coordinated the initial incorporation process for the society (see "Professional and Community Activities of the Staff," *MHRI Bulletin* [1960]: 5).

102. Miller, "The First Five Years," p. 47. See also Medical School Records (MED, Box 172). One of largest grants was awarded by the National Institute for Mental Health for the Schizophrenia and Psychopharmacology Project, under the directorship of Gerard.

103. Miller "Findings from Research," in "The First Five Years," pp. 49–56; Medical School Records, p. 29; Mental Health Research Group, "Activities of Mental Health Research Group," March 1956 (MED, Box 63), p. 2.

104. James Grier Miller, "Editorial," *Behavioral Science* 1:1 (Jan. 1956): 1–4 (quote p. 2). In addition to Miller, Gerard, and Rapoport, the editorial board included Franz Alexander, Alex Bavelas, David Easton, Clyde Kluckhohn, Marion J. Levy, Donald Marquis, Jacob Marschak, Ralph Tyler, and Raymond Waggoner.

105. Ralph Gerard, "Memorandum No. 18: Theory Group 4/4/56" (RWG, Box 10).

106. "Joint Book on General Behavior Theory" (RWG, Box 10), pp. 1–16. This collaborative project was often referred to as the "Bourbaki" book, after a famous group of mathematicians who published collectively under the assumed name of Nicholas Bourbaki.

107. "Committee on Behavioral Science: National Support for Behavioral Science" (RWG, Box 12), pp. 10–11; "Draft of Report of first meeting of NAS-NRC Committee on the Behavioral Sciences" (RWG, Box 12), p. 1; Miller, "The First Five Years," p. 47; "Services in the Community, State, and Nation," *MHRI Bulletin* (1958): 20–21; Miller, "The Scientific and Professional Activities," p. 13. Other members of the committee included Raymond Bauer (Harvard Business School), George Berry (Harvard Medical School), Paul Buck (director of Harvard University Library), Bentley Glass (professor of biology at Harvard), Rev. Leslie Glenn (MHRI), Max Millikan (MIT Center for International Studies), Frank Stanton (president, Columbia Broadcasting System), Samuel Stouffer (director of Laboratory of Social Relations at Harvard), and John Whitehorn (Johns Hopkins Medical School).

108. "Committee on Behavioral Science: National Support," pp. 10–11; Miller, "Statement of the Director," *MHRI Bulletin* (1960): 7; Miller, "The Scientific and Professional Activities," p. 13. Rapoport established ongoing connections with the Institute of System Research in Moscow, which published a yearbook similar to *General Systems,* entitled *Sistemnyie Issledovania* ("systemic investigations").

109. Miller, "Professional and Community Activities," pp. 34–37. Flood was involved with a marketing simulation project for General Electric that was carried out at MHRI. Meier also worked closely with Russell Ackoff in connection with his work on urban planning. In the early 1960s Gerard began to work on a proposal for an Adaptive Systems Research Lab. In 1960 Gerard coordinated a conference on adaptive systems in association with The Institute of Management Sciences and Institute of Science and Technology, which was held at MHRI. Russell Ackoff and West Churchman, who were both active in SGSR, were in attendance at this meeting (see "Proposal for Adaptive Systems Research Lab, June 1962," RWG, Box 11).

110. James Grier Miller and Jessie L. Miller, "Cybernetics, General Systems Theory, and Living Systems Theory," in Ralph L. Levine and Hiram E. Fitzgerald, eds., *Analysis of Dynamic Psychological Systems,* Vol. 1: *Basic Approaches to General Systems, Dynamic Systems, and Cybernetics* (New York: Plenum Press, 1992), pp. 9–34 (quote p. 34). In her comments at the dedication of the James Grier and Jessie Louise Miller Information Technology Center at the University of Louisville, Linda Peeno pointed out that living systems theory was more influential outside of the United States and that it had been applied in a number of fields, including science, politics, economics, medicine, and education. In Buenos Aires, for example, it was used as a model for the treatment of psychiatric disorders.

111. Ibid., pp. 9–11.

112. James Grier Miller, "Some Notes on Information Theory," *Journal of Medical Education* 39:11 (Nov. 1964): 182–189; Miller and Miller, "Cybernetics," pp. 13, 33–34.

113. Virchow quote from Rudolf Virchow, "Atome und Individuen," *Vier Reden über Leben und Kranksein* (Berlin: Georg Reimer, 1862), cited in James Grier Miller, "Living Systems: Basic Concepts," *Behavioral Science* 10 (1965): 237.

114. Miller, "Living Systems: Basic Concepts," pp. 193–237; Miller and Miller, "Cybernetics," p. 26; Boulding, "Universal Physiology," pp. 687–691; Daniel Dobbert, "Review of Miller's *Living Systems,*" *Futurics* 3:3 (1979): 298–300. Miller and Miller, "Cybernetics," provides an excellent and accessible summary of the framework introduced in *Living Systems*. Along with the addition of the timer as the twentieth subsystem, Miller's later work also included an eighth level (the community) in between the levels of the group and the society.

115. Miller and Miller, "Cybernetics," pp. 28–31; Alfred Kuhn, "Differences vs. Similarities in Living Systems," in "Symposia," *Contemporary Sociology* 8:6 (Sept. 1979): 693.

116. Kuhn, "Differences vs. Similarities," p. 694; James Grier Miller, "Response to the Reviewers of *Living Systems*," in "Symposia," *Contemporary Sociology* 8:6 (Sept. 1979): 708–709.

117. Miller, "Response to Reviewers," pp. 712–713; Miller, "Basic Concepts," pp. 220–221; Miller and Miller, "Cybernetics," p. 31.

118. Miller, "Basic Concepts," pp. 229, 232–233; James Grier Miller, "Living Systems: Cross-Level Hypotheses," *Behavioral Science* 10 (1965): 394, 397.

119. Miller, "Living Systems: Cross-Level Hypotheses," pp. 403, 406; also "Basic Concepts," p. 231.

120. Miller, "Living Systems: Structure and Process," *Behavioral Science* 10 (1965): 370–371, 376.

121. Boulding, "Universal Physiology," pp. 690–691.

122. Rapoport, *General System Theory,* p. 23–26; Kuhn, "Differences vs. Similarities," pp. 694–695; Miller, *Living Systems,* p. 1025.

123. Miller, "Response to Reviewers," pp. 706, 710–711; *Living Systems,* p. 1025; Miller and Miller, "Cybernetics," pp. 21, 26; Boulding, "Universal Physiology," p. 689; Talcott Parsons, "Concrete Systems and 'Abstracted Systems,' " in "Symposia," *Contemporary Sociology* 8:6 (Sept. 1979): 697. While Parsons is sympathetic with Miller's general approach, he disagrees with his emphasis on the importance of quantification in advancing science (see Miller, "Response to Reviewers," p. 715).

124. Miller, *Living Systems,* p. xv; Boulding, "Universal Physiology," p. 691; Anatol Rapoport, "The Uses of Mathematical Isomorphism in GST," in George Klir, ed., *Trends in General Systems Theory* (New York: Wiley-Interscience, 1972), p. 44. See also David Berlinsky, *On Systems Analysis: An Essay Concerning the Limitations of Some Mathematical Methods in the Social, Political, and Biological Sciences* (Cambridge, MA: MIT Press, 1976), p. 21.

125. Anatol Rapoport, "Foreword," in Walter Buckley, ed., *Modern Systems Research for the Behavioral Scientist: A Sourcebook* (Chicago: Aldine, 1968), p. xxii.

126. Mark Davidson, *Uncommon Sense: The Life and Thought of Ludwig von Bertalanffy (1902–1972), the Father of General System Theory* (Los Angeles: J. P. Tarcher, 1983), p. 33.

EIGHT
Kenneth Boulding (1910–1993): Economics, Ecology, and Peace

So, will the century twenty-first
Be with the growth of fat accursed,
Or will we have the luck to see
The world move to maturity,
When on this planet we call native,
Our growth gets mostly qualitative.
The price that we will have to pay
For going the maturer way,
Is to abandon the pretense
Of violent national defense.

—Kenneth Boulding, from "A Ballade of Maturity"[1]

Kenneth Boulding read his "A Ballade of Maturity" at the annual meeting of the American Association for the Advancement of Science in 1991. Written in his own unique style, the poem brings together the three dominant themes in his life's work: economics, ecology, and peace. In the opening lines, he notes that once humans have reached adulthood, further growth "in terms of weight, means getting fat would be our fate." The same, he says, is true of wealth: "It's good to have the poor get rich, but past some point, riches are kitsch." Boulding actually introduced the concept of "spaceship earth" to challenge the unrestrained exploitation of "cowboy economics," and his work inspired the steady-state economics of Herman Daly. Closely aligned with his economic views, Boulding's commitment to peace and nonviolence was a central focus of his life's work, reflected in his emphasis on humility, flexibility, adaptability, and the willingness to see different points of view. His most endearing feature, gracing his talent for dramatic and effective communication, was his keen wit and impish sense of humor.

Growing out of childhood experiences during World War I, Boulding's conception of general systems theory was rooted in a profound opposition to war. The key themes in his contribution to the development of general-systems thinking include his ecological conception of society, his development of the insights of information theory and cybernetics into an analysis of perception and ideology, and his lifelong commitment to peace and conflict resolution, which framed his evolutionary view of history. Informing each of these themes was an inquiry into the nature of human values and the processes of their formation.

Originally trained as an economist, Boulding's scope of interest was extremely broad. Refusing to be constrained by disciplinary boundaries, he sought to synthesize diverse views regarding the nature of humanity and its relation to the natural world, and to integrate diverse approaches to solving the complex problems facing the mid-twentieth-century world. This passion for fostering the broader view was at the heart of his motivation in founding the Society for General Systems Research (SGSR). Boulding was a highly creative and original thinker, although his influence in the general-systems community clearly had as much to do with the power and passion of his personality. Everyone who knew him spoke of him with a great deal of affection. Though I never met him, I got the sense that he was truly a person of integrity who embodied his intellectual commitments in his very being.

Boulding's frustration with the narrow limitations of most economic thought is summed up in characteristic style in the following:

> Economists are understood
> To study goods, if not the Good,
> Although their goods, we often find,
> Are pale abstractions of the mind.[2]

As an economist, he was concerned far more with the Good than he was with commodified goods. His presidential address to the American Economics Association in 1974 was entitled "Economics as a Moral Science." He began his study of economics at Oxford in 1929, after a year of studying chemistry. In the context of the Great Depression, it seemed to him the critical key to the improvement of human welfare, which was his life-long concern: "As an earnest young man wanting to save the world, I was pretty sure chemistry wouldn't do it. At that time the great problems of the human race seemed to be economic." While he received numerous awards for his contributions, including the John Bates Clark Medal from the American Economics Association in 1949, as well as nominations for the Nobel Prize in economics and the Nobel Peace Prize, he often expressed his regret that no one seemed to be listening to what he had to say.[3]

Boulding decried what he saw as the narrow focus on commodities as the primary abstraction in contemporary economics, completely neglecting the role of human values and preferences (not to mention other species) in its models of economic exchange. Although the market is supposed to be the perfect measure of human value, anything that cannot command a price in the marketplace becomes invisible in determinations of value. Boulding's interest in a broader study of the social sciences, like his interest in general systems, grew out of his desire for greater insight into the social and psychological roots of human behavior. The model of rational man embodied in economic theory was obviously inadequate, and he hoped to gain a better understanding of the complex factors motivating choices in economics as well as in other kinds of interactions. As he said, there is "no such thing as economics, only social science applied to economic problems," and furthermore, "all social sciences are fundamentally studying the same thing (the social system) from different points of view."[4]

Although he was awarded thirty-six honorary degrees, Boulding never received a Ph.D., which didn't prevent him from participating actively in the academic world. He was president of both the American Economics Association and the Association for the Study of the Grants Economy in 1968, the International Studies Association in 1974, and the American Association for the Advancement of Science (AAAS) in 1979. He was a fellow in both the American Academy of Arts and Sciences and the American Philosophical Society, and a member of the National Academy of Sciences. In addition to founding SGSR, he contributed substantially to the development of the fields of grants economics, ecological economics, future studies, and peace research and conflict resolution, founding several related organizations including the Center for Research on Conflict Resolution, the International Peace Research Institute, the Peace Research Society International, and the Association for the Study of the Grants Economy.[5]

He was considered a world authority on peace and conflict studies; his book *Conflict and Defense* became the most commonly cited reference in the growing field of peace research. The largest category of his writing was in this area, which he considered the most important dimension of his work, reflected in his active involvement with the Quaker community. His contributions in the field of economics, however, were also substantial. First published in 1941, his *Economic Analysis* went through four editions and was translated into several languages including Japanese, Turkish, and Burmese; it was the standard economics text until it was replaced by Paul Samuelson's. Described as "the first modern textbook on economic theory," it offered a coherent synthesis of Keynesian and neoclassical economics. With John Kenneth Galbraith and Robert Heilbroner, Boulding was one of the foremost proponents of Keynesian economics, having been disillusioned with Marxism and socialism during his college years. In line with his systems orientation, he described Keynes's view as Copernican rather than Ptolemaic, looking at the economic system as a whole rather than through the perspective of the individual.[6]

Boulding published roughly forty books, over eight hundred articles, and three volumes of poetry, having written several hundred sonnets over the course of his life. Reflecting his characteristic modesty, Boulding describes himself as "a rather minor figure in the history of American thought." In spite of his academic accomplishments, he remained somewhat of an outsider, with a penchant for controversial and unconventional views. In her biography of Boulding, Cynthia Kerman quotes one reviewer that describes him as "much admired as an economist by noneconomists," and another that says "every professional reader will doubtless be impressed both by the wisdom of Boulding's discourse in areas outside the reader's competence and by its shortcomings within that area." His son William remarks that he had provoked economists until they disowned him. Boulding himself notes that in a history of the Economics Department at the University of Michigan, written for the hundredth anniversary celebration, he was dismissed as having lost interest in economics, in spite of the fact that he had been president of the

American Economics Association during the last of his eighteen years in the department and was still actively engaged in the profession.[7]

It was not only his interdisciplinary interests that tended to marginalize him. His son also mentions that Boulding was the only president of the AAAS who wrote books of religious poetry and talked openly about his divine revelations, marginalizing him even further from the predominately secular orientation of the academic community. According to Boulding's own perspective on the dilemma, "Communication between the intellectual and the religious subcultures is perilous in the extreme. It depends almost entirely upon the doubtful abilities of a few individuals who participate in both. Society owes an enormous debt to those marginal men who live uneasily in two different universes of discourse. Society is apt to repay this debt by making them thoroughly uncomfortable and still more marginal."[8]

Boulding used simple language and colorful analogies to communicate his ideas, belying the sophistication of his thought. With his hawklike features and wild mane of long white hair, his appearance became increasingly striking with age. Former Colorado governor Dick Lamm noted that he "always had a twinkle in his eye." He possessed a masterful and piercing wit, which was not in the least impaired by a pronounced stutter. In fact, as he grew older, he learned to use his speech defect for dramatic emphasis. He was a brilliant and highly sought-after lecturer. According to his wife, Elise, he saw things that others did not and had a passion for making connections. He had a remarkable ability to bring together people of "widely different passions and convictions." In addition to being a poet, he was a painter, a sculptor, and an aspiring composer, having been enchanted in his youth with the musicals of Gilbert and Sullivan, prompting a quip that "he was the very model of a modern major generalist."[9]

Boulding was highly unorthodox and delighted in taking outrageous positions, always challenging his audience to think about things in a different way. In a lecture to the top managers of Bell Telephone, he wore a button that read (in large letters) "To Hell with Bell Tel." In response to a request to present a keynote address at a conference on the role of scientists as members of society, sponsored by Dow Chemical, he agreed to come only if he could speak on the "Ethics of Napalm." *The London Independent* describes him as "using his wicked wit to expose the dangerous illusions and hypocrisies of those in power, but always sustaining a civil discourse that allowed opponents the space to respond." One of his primary goals was to break down the boundaries between different "universes of discourse" and to create meaningful dialogue between different subcultures.[10]

Although many of his ideas were fairly radical, he transcended the categories of left and right; his economic views were actually fairly moderate. The *New York Times* describes him as "half Milton Friedman and half Mahatma Gandhi." According to Kerman, he was a heretic even among radicals, constantly attempting to bridge polarizing forces and combine opposing points of view, challenging traditional divisions along party lines. While he was generally sympathetic with its progressive ideals, he became increasingly disillusioned with the Democratic Party during the Johnson administration, primarily but not exclusively because of its military agenda in Vietnam. He wrote that the crisis of the Democratic Party was a crisis of hypocrisy: "It pretends to help the poor but on the whole it does not. Most of [its] policies have in fact subsidized the rich." He described the labor movement as "a highly conservative and establishment-minded force," arguing further that it "does not go very far toward meeting the needs of those who tend to be excluded from the benefits of our society," and that it has lost the "genuine concern for human nature which gave rise to it."[11]

Although equally critical of the right, he registered as a Republican in 1970 and became the faculty advisor for the Young Republicans at the University of Colorado in Boulder, after having been a faculty sponsor of the Students for a Democratic Society in Michigan five years earlier. In a letter to Vice President Hubert Humphrey, Boulding wrote that the Johnson administration was "the most tragic and disastrous almost in the history of the United States." He wrote to David Riesman that he despaired of the Democratic Party and that he had resigned his membership: "It has been in office too long, it is too much committed to the labor movement, to the military-industrial complex, and to the big city machines." Although he saw the right wing of the Republican Party as ignorant and malevolent, he did see some promise in the Ripon Society, which he compared with the Fabian Society of the 1890s.[12]

Boulding believed that the study of values and underlying assumptions was of primary importance in social science. Building on Pierre Teilhard de Chardin's model of the evolutionary potential of the "noosphere" (the sphere of the mind), he foresaw an evolutionary movement of human valuations toward increasing maturity. This was an important aspect of his conception of the systems view, which he saw as a way of looking at things, a mode of inquiry rather than a rigid model of nature. He was critical of overly structured models, as "the bulging and slatternly corpus of knowledge obstinately refuses to fit the neat corsets of the system builders." And he was sensitive to the tension between systematic and particularist views of reality:

> Humor has strong roots in the desire to deflate the pomposity of imposed systems which do not recognize the chaos and absurdity of much of the real world, . . . [which], as William Blake says, consists of minute particulars. There is a deep tension between the perception of the real world as utterly diverse and private, reflected philosophically, perhaps, in solipsism, and the rage for order that we have that drives us to a passionate desire to experience the world as a unity.

He describes these two views as "alternative and competing systems which constitute what might be called ideologies," highlighting his interest in the role of ideology in the evolution of knowledge.[13]

While he believed that knowledge provided an essential basis for any kind of social change, he constantly emphasized the importance of considering a wide variety of theoretical perspectives and practical approaches. His ideals were based on a pluralistic conception of the universe that would support many centers of power and a diversity of ethical values. In his typical style, he suggests that pride is the greatest sin, because it interfers with the ability to learn. "The world is a very complex system. It is easy to have too simple a view of it, and it is easy to do harm and to make things worse under the impulse to do good and make things better." The meek, he says, will indeed inherit the earth because they are more adaptable.[14]

Closely related to his passion for peace and social justice was his concern with the environment. In an article for the *Encyclopedia of the Environment,* Gilbert White writes that Boulding "helped place the examination of environmental problems in intellectual frameworks embracing both social and natural sciences in the 1950s." He was a participant in the 1955 Princeton conference on "Man's Role in Changing the Face of the Earth" and actively involved in reformulating energy policy in the 1970s. His work in this area contributed substantially to the emerging field of ecological economics. The following passage illustrates his perspective on the relationship between systems thinking, peace, and ecology:

> General Systems should lead to a kind of environmentalism of the mind, a delight in the great variety of the world. It should enable us to see the world of human ideas as indeed an ecosystem, fostering immense variety, and not as an organism demanding subordination to a central authority. . . . [The catastrophe of nuclear war] is all the more certain when conflicts are couched in ideological terms. It is therefore of immense importance to look at the earth as a total system in which only a tolerant ecological view can save us.[15]

FROM LIVERPOOL TO BOULDER: THE QUEST FOR PEACE AND JUSTICE

Kenneth Ewart Boulding was born in Liverpool, England, on January 18, 1910, the only child of William Couchman Boulding and Elizabeth Ann Rowe Boulding. He was also an only grandchild, so much of his childhood was spent in the company of adults. His father and his maternal grandfather were both Methodist lay preachers, and some attribute his belief in human betterment to this upbringing in the Methodist Church. As Kerman points out, the Methodist Church was mostly working-class and played an important role in increasing educational opportunities for the poor and elevating the laity through the practice of lay ministry. In his own reflections, Boulding also notes an emphasis on freedom of the will as characteristic of Methodism.[16]

William Boulding was a plumber and heating engineer, although he was not very successful as a businessman. When he died in 1933, his debts were nearly double his assets. He often did work for local churches at or below cost, volunteered with disabled children, and took in the homeless. His was active in the Liberal Party, naming his son after the Liberal prime minister William Ewart Gladstone. While Kenneth was more successful in managing his affairs, he shares this generosity of spirit that bankrupted his father. From his mother he got his passion and talent for poetic expression.[17]

Boulding was a pacifist even as a child; his experiences of World War I instilled in him an abhorrence of violence that would remain with him for the rest of his life. A typical entry in the journal he kept during this period would begin: "1,478th day of war." At age nine he began publishing a newspaper, which gained him quite a following in the local neighborhood. As he says, he learned that "the typewriter was much mightier than the fist." By the time he was fourteen, he had discovered the Quakers through a tract on conscientious objection. Their lack of creedalism and tolerance of diversity appealed to him, fostering his distinctive view of systems through their understanding of freedom within order, which was "not programmed but which emerged out of a larger underlying reality." Other significant influences during this period of his life were H. G. Wells, George Bernard Shaw, and Gilbert and Sullivan, who helped to shape his iconoclasm and his wit.[18]

Boulding's headmaster in grammar school was a socialist and an atheist, nurturing his appreciation for diversity of opinion and giving him permission to question established beliefs. Although he was at first considered retarded because of his stuttering, his teachers soon recognized his ability and he was tutored for the scholarship competition for Liverpool Collegiate, where he spent six years before winning a scholarship in chemistry at New College, Oxford, in 1928. After his first year, he decided that his concern with human welfare might be more adequately served through the study of the "modern greats"—economics, politics, and philosophy—and he got permission to switch his course of study while keeping his scholarship. He graduated in 1931 with "first class honors" (the highest "first" in economics) and stayed on for a year of graduate study for which he received a master's degree in 1939. In 1931 he wrote a paper on "The Place of the 'Displacement Cost' Concept in Economic Theory" that was published in the *Economics Journal,* edited by John Maynard Keynes.[19]

Evidence of his interest in multiple perspectives can be seen in his desire to join all three political parties when he first entered Oxford. He was most sympathetic with the socialists during his early years, however, upsetting his liberal father by supporting the Labor Party. Ultimately, he rejected socialism, after the political defeat of the Labor Party in 1931 and further exposure to Marx's work. In 1930 he wrote papers criticizing the materialist conception of history and the labor theory of value, which remained the primary issues in his objections to Marxist theory. He did not accept the idea of a sudden revolutionary transition; he thought instead that the desired social change would require "long periods of education to prepare the masses of people for the responsibilities and skills required in their new roles as decision makers and full participants in a technological society." His criticism of the labor theory of value was grounded in his perception of valuation as a property of the mind, a frequent theme in his later work. In November 1930 Keynes gave a lecture at Oxford, and Boulding found his intellectual mentor.[20]

In 1932 Boulding was awarded a Commonwealth fellowship for two years of study in the United States. He spent the first year at the University of Chicago, in the early years of Robert Hutchins's presidency. During the fall of 1933 he studied at Harvard with Joseph Schumpeter, whom he had originally met on the boat coming over from Great Britain. He returned to Chicago in spring 1934, where he was most influenced by the work of Frank Knight. Boulding wrote an article challenging Knight's application of population theory to the theory of capital. This approach was very influential in Boulding's own ecological perspective on capital, although he argued that Knight had failed to take into account the age of capital, which, like living organisms, also goes through cycles of birth, decay, and death. In response, Knight wrote a scathing article on "Boulding and the Austrians" in the *Journal of Political Economy,* which Boulding claims gave him all the academic credentials he needed. Also influential during this period were Irving Fisher, whose ideas Boulding developed in his work on sustainable economics, and Henry Schultz, one of the founders of econometrics. Boulding later commented that if Schultz had lived longer, the development of econometrics might have taken a very different course, with a far greater emphasis on empirical work rather than abstract modeling. His advisor at Chicago, Jacob Viner, suggested that he work toward a Ph.D., but after asking what it would entail, Boulding replied, "If I do that I will become a broken man."[21]

The terms of his fellowship required him to return to Britain; in fall 1934 he found a teaching position in Edinburgh, Scotland. After Chicago he found the atmosphere somewhat stifling and his three-year position was not renewed after he suggested, in a talk he gave at a program on university education in April 1936, that the Scottish university system had been sitting on its haunches for the last fifty years. He was very active in the Quaker community during this period, however, writing a pamphlet on nonviolent methods in 1936 and drafting a letter for the Friends to the prime minister, asking Britain to disclaim the "war guilt" clauses in the Treaty of Versailles and move toward a more just peace. The following year he attended the Friends World Conference in Philadephia and, through connections with a former fellow student from Chicago, was offered a position at Colgate University in upstate New York, where he stayed until 1941. Boulding was a heretic even among the Quakers in New York, who rebuked him for inviting a black man to dinner at his home. During this time he continued to refine his ecological models. A letter he wrote in 1935 addressed the importance of understanding the interaction of any system with its environment. This theme was developed further in 1948 in his description of society as a pond, echoing Bertalanffy's open-system concept. The first chapter of his book *A Reconstruction of Economics,* published in 1950, is devoted to a discussion of society as an ecosystem. This was followed in 1955 by a paper analyzing the automobile population from an ecological perspective.[22]

In spring 1941, at another Quaker conference, he met Elise Bjorn-Hansen, whom he married shortly thereafter. He took a job with the economic and financial section of the League of Nations that fall, doing research on the recovery of European agriculture after World War I. This work informed his analysis of reconstruction and the development of the postwar world in his *Economics of Peace,* published in 1945, in which he argued for the necessity of socially responsible organizations and a sense of world citizenship. With Elise, he drafted a statement calling for disarmament and was told that he would lose his job if he released it. He chose to resign from his post, in a move that was typical of his commitment to his beliefs. Similarly, when faced with the draft, he was willing to go to jail and forfeit his chance at American citizenship to avoid enlisting, although he was instead given a 4-F classification. While he and Elise had been prepared for hardship after he left the League of Nations, he was offered a position at Fisk University in Tennessee. Boulding claims that a half-hour conversation about social ecology with Robert Park, who was also at Fisk that year, changed his life, further stimulating his interest in ecology and evolutionary theory. As he later reflected, when he was willing to make sacrifices for his beliefs, things generally worked out for the better. He was awarded his U.S. citizenship in 1948.[23]

In 1943 Boulding was offered a position as a labor economist at Iowa State College in Ames. Theodore Schultz, the chair of the department, had been looking for an impartial economist with no prior experience in that particular field. An excellent opportunity for Boulding, it further convinced him of the need for a more integrated approach to the study of social phenomena. He visited eighty-five head offices of unions around the country and nearly every local union, an exercise in "casual empiricism" that he found extremely valuable. The process convinced him that the labor movement could not be understood without incorporating political, sociological, psychological, and anthropological perspectives. A weekly social-science seminar fostered Boulding's increasingly interdisciplinary orientation. While in Ames, he worked with the Committee for Economic Development, concerned primarily with the economic transition from war to peace, a recurrent theme in his later work. During the 1946–1947 academic year, he was chair of the Economics Department at McGill University in Montreal, and then returned to Iowa State where he stayed until 1949, when he was offered a position at the University of Michigan. Describing his professional goals in 1948, Boulding wrote that he was interested in developing a theory of the "'social organism,' . . . in applying the techniques of sociology and anthropology to economic phenomena, . . . [and] in applying the methods and insights of economics to other social sciences, particularly political science." As Cynthia Kerman describes him, he was trying to "tie together economic man, biological man, sociological man, psychological man, and perhaps even religious man, and bring the fragmented back together again."[24]

A Reconstruction of Economics, which Boulding considered his major theoretical work in the field, provided the first comprehensive elaboration of his ecological theory of capital. Although he later acknowledged the shortcomings of the book, he thought its fundamental arguments were still valid. His last book, *The Structure of a Modern Economy,* published posthumously in 1993, develops themes that were central to this earlier work. Throughout his writing, he challenges the exclusive emphasis on the flow of money and goods, and the resulting dependency on continual economic growth, that characterizes modern economic theory. In *Principles of Economic Policy,* published in 1958, he argues for a reexamination of the goals of economics and a reordering of the relative priorities of progress, stability, justice, and freedom. He notes that "the object of economic activity is not consumption but use." By emphasizing income-flow concepts, traditional economics encourages the maximization of consumption and production. In contrast, Boulding's emphasis on capital-stock concepts calls for a minimization of both. This kind of thinking inspired his concept of the "spaceship" economy, formulated in 1966, and underlies his influence in the development of steady-state economics.[25]

The concept of mutual determination was fundamental to Boulding's understanding of the structure of social reality as a system of populations. Drawing on this demographic model, in which the equilibrium size of any population is a function of all the others, he describes capital in terms of ecological relationships between firms. Although true equilibrium does not exist in the natural world, since all things are subject to the processes of entropy, he suggests that all systems are organized to maintain a particular state. As a result, Boulding noted the need for a theory to explain the pressures for change operating against resistance, pointing out that human behavior might be determined more by inertia and the principle of least resistance than by rational attempts at maximizing advantage.[26]

Boulding's interpretation of the relevance of cybernetics for social theory is apparent in the following comment from *A Reconstruction of Economics:* "The development of adequate cybernetic mechanisms for a free economy, which will not achieve stability only at the cost of tyranny or stagnation, is a project of first priority, exceeded in urgency perhaps only by the necessity of developing similar cybernetic mechanisms for the stabilization of peace." Linking the cybernetic idea of homeostasis and Keynesian economics, he assigns these regulatory mechanisms to the agency of government. In addition, however, he argues that economic life must be understood as an aspect of the whole complex of social relationships: "Too often the system-maker (the economist is not the only delinquent here) uses the convenient distinction between the endogenous factors which constitute his system proper and the exogenous factors which operate as disturbing forces from the 'outside' as an excuse for not thinking at all about the inconvenient 'exogenous' factors." While conceding that partial systems could be useful, he was concerned that specialists in the various fields of social science recognize the partial nature of their own models and at least be aware of other aspects.[27]

Providing the foundation for his understanding of general systems, Boulding's interdisciplinary approach to the social sciences was consolidated after his move to the University of Michigan in 1949. The year he spent at the Center for Advanced Study in the Behavioral Sciences (CASBS), 1954–1955, was clearly one of the most influential experiences during this period, providing the inspiration for the SGSR as well as his ongoing work in peace research. The Center for Research on Conflict Resolution was established in 1957, and Boulding became editor-in-chief of the *Journal for Conflict Resolution*. He was actively involved in the antiwar movement of the 1960s. In April 1958 he initiated a vigil in protest of nuclear testing, standing at a flagpole in the center of campus in a symbolic statement of nonconsent. In 1960 he stood in front of the Pentagon in another protest vigil with a thousand fellow Quakers. He was a sponsor of the first teach-in on the Vietnam War on March 24, 1965. His role as one of first social scientists to join the physical scientists in the Pugwash's Conference on Science and World Affairs in 1962 further demonstrates the breadth of his interdisciplinary focus.[28]

Boulding stayed at Michigan until 1968 when he was offered a position at the University of Colorado, where he had been a visiting professor of economics the previous year. Part of the reason he went to Boulder was that he felt he could contribute more to a younger institution. Given his frustration with the limitations of the traditional disciplinary structure, perhaps he felt that a newer institution might provide more opportunity for innovation in this regard. His position was half-time as professor in the Department of Economics and half-time as director of the Program of Research on General Social and Ecological Dynamics for the Institute of Behavioral Science (IBS). Through the IBS program, he offered a course with his wife, Elise, on the "Social System of Planet Earth," which was a culmination of their collaborative work in interdisciplinary approaches to the social sciences and his own work on general systems. In 1977 he was named distinguished professor of economics. Although he retired in 1981, he remained actively engaged in the fields he had done so much to promote until his death on March 18, 1993.[29]

MICHIGAN: THE FORD FOUNDATION AND THE BEHAVIORAL SCIENCES

In December 1954, while he was in residence at the CASBS, Boulding was invited to speak at UC Berkeley on the relationship between economics and the behavioral sciences. He began his address with the assertion that "we are living in the midst of an interdisciplinary movement." He went on to describe this movement as resulting from three developments: the growth in generality of the disciplines to the point where the divisions between them were beginning to break down; the development of a number of empirical fields, such as industrial relations, that drew on theoretical bases from several different disciplines; and the growth of "interstitial" fields, such as social psychology. Reflecting the development of his own work, he suggested that the influence of biological theories of growth, ecological succession, population interaction, and homeostasis was an important factor in this integrative process, as were the emerging fields of cybernetics and information theory. Significantly, he noted the influence of the Ford Foundation in its support of the behavioral sciences, suggesting that a good operational definition of a "behavioral science" was "one that gets money from the Ford Foundation." Indeed there was a fairly strong convergence between his personal and professional goals and those of the Ford Foundation.[30]

The description of the foundation's program on individual behavior and human relations (quoted at the beginning of Chapter 1), which resulted in the establishment of CASBS, echoes concerns central to Boulding's argument in *The Organizational Revolution,* published in 1953:

> In a world whose people are becoming rapidly more interdependent and in which the external forces which control them are becoming more centralized, there is urgent demand for a rational basis for planning and responsible decision making. At the same time individuals require an understanding of human behavior if they are to help maintain the democratic nature of such planning and control.

Boulding's own work, commissioned by the Federal Council of Churches under a grant from the Rockefeller Foundation, analyzed the ethical impact of large, centralized organizations.[31]

Concerned primarily with the preservation of freedom and justice, *The Organizational Revolution* makes the case for a limited government. Basing his argument on a fundamentally cooperative ecosystem model, Boulding discusses the similarities between social organizations and biological organisms, describing how the behavior, growth, and survival of organizations at both levels are determined by their internal structures. Central to his analysis is an understanding of structural limitations on growth, building on the idea that doubling a linear dimension, for example, increases area by a factor of four and volume by a factor of eight. Since lines of communication are linear, as are nerves, Boulding suggests that as the size of social organizations increases, communication networks and administrative roles have a greater relative importance. These functions were significantly enhanced by technological changes that improved organizational skills and extended the previous limits to organizational growth, motivating Boulding's analysis of the effect of such growth on the nature of the marketplace and the increasing power of the state.[32]

Boulding summarized these themes in a paper entitled "The Taming of Mammon: The Great Change in Economics," which he wrote while he was at CASBS. He describes a revolution in the skills of organization and society that took place between the two world wars, reflecting a change in theory, information, and policy, embodied particularly in Keynes's suggestion that government is responsible for full employment and economic stability. Similar concerns motivated the founding of the Center for the Study of Democratic Institutions, with which both Boulding and James Miller were associated. With Robert Hutchins as president, its goal was to maintain "a free, just, and democratic society" in an increasingly "bureaucratized, industrialized, and polarized world." Their primary concern was the potential impact of large institutions, such as corporations, labor unions, military establishments, mass media, and political parties, on traditional concepts of freedom and justice.[33]

For Boulding, the strength of capitalism was its "ability to coordinate organizations into an ecosystem that is not centrally integrated." Based on this "ecological" view of social organization, he was fundamentally opposed to concentrations of power. He was particularly concerned with the potential for coercion that resulted from the organizational changes described above. He argued that the "rise of organizations increases the necessity of internal democracy within the organizational structure if liberty is not to be endangered" and sought ways to foster communication and responsiveness within increasingly hierarchical organizational structures.[34]

Circular cybernetic models were central to this project, incorporating receptors and transmitters of information, executive functions that determine appropriate action in response to inputs, and transmitters of orders and effect, that would be fed back into the initial receptor (see Figure 8.1). The role of the receptors was to register any divergence in the environment from ideal conditions. While democ-

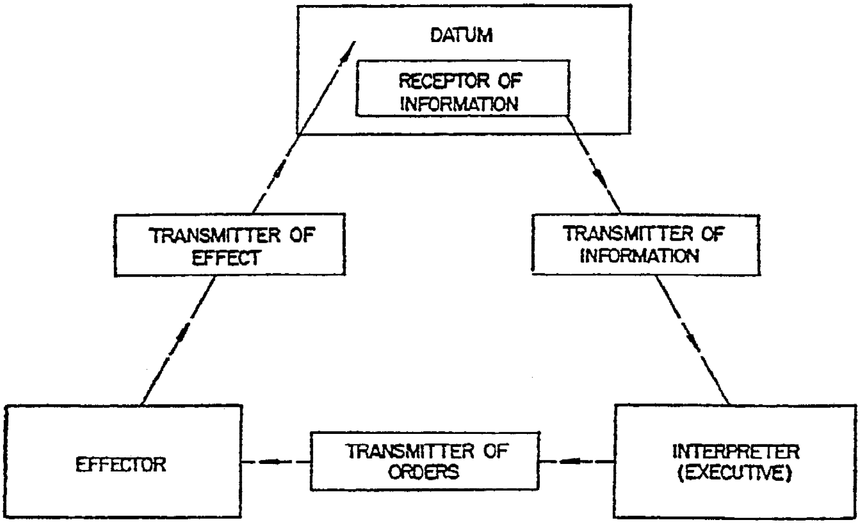


Figure 8.1. Kenneth Boulding's Feedback Model. Source: Kenneth Boulding, *The Organizational Revolution: A Study in the Ethics of Economic Organization* (New York: Harper, 1953), p. xxviii. Diagram reprinted from the *Papers of the Michigan Academy of Science, Arts, and Letters,* vol. 37, 1952, p. 278.

racy is theoretically supposed to serve this function, creating a kind of circular hierarchy, Boulding noted that communication up the hierarchy is usually weak. He recognized that the determination of the ideal state, as well as the response to any input of information, would reflect the biases of the executive. As he said, "The mind may be accurately informed about the present state of the world, but may not perceive that this state is abominable." Still, fundamental to his belief in the potential for constructive change was the idea that living systems are capable of learning.[35]

Based on this analysis of communication in organizations, Boulding identifies interpersonal relations as an essential aspect of the individual's economic experience, suggesting that neurotic personalities might transfer "frustrated personal relationships" into aggressiveness and ambition. A thorough evaluation of organizations would thus require an analysis of the process by which individuals rise to positions of authority, thereby determining the type of personality that would attain power in these organizations. It would also require a better understanding of potential sources of autonomy to overcome the increasing efficiency of coercion.[36]

C. E. Ayers wrote to Boulding in 1955, suggesting that his *Organizational Revolution* was a conversion to the institutionalist view. Although previously somewhat critical of this school of thought, which included the work of Thorstein

Veblen, John Commons, and Wesley Mitchell, Boulding responded, "I think perhaps in years to come they will be seen as the fore-runners of a truly integrated social science which I think today is in the making," although their efforts toward an integration of the social sciences were premature. Inspired by this exchange, Boulding wrote "A New Look at Institutionalism," describing it as a tradition of dissent focusing on the orthodoxy of economic thought, as well as the economic institutions themselves—essentially a moral critique "arising from the belief that orthodox economics is a defender of ethically undesirable institutions." Their attempts at a broad synthesis of social theory in their economic models were limited by the views of their times. Veblen, for example, had drawn upon "instinct psychology, a racist anthropology, a mechanistic biology, and an analogical sociology, and the result was hardly a durable system." Nevertheless, Boulding acknowledged that the sources of dissent were still valid and that the institutionalists had raised important issues, such as the need for empirical feedback, dynamic models, and integration with other social sciences, which were reflected in such contemporary developments as cybernetics, operations research, general systems theory, organization theory, and "even in the humble contributions of a few economic theorists."[37]

Although Boulding's interest in interdisciplinary studies can be traced to his early use of ecological metaphors and population models in his studies of capital beginning in Chicago, as well as his work on labor theory at Iowa State College, the critical synthesis emerged in connection with his interdisciplinary seminars in Ann Arbor. Even here the influence of the Ford Foundation was significant. Shortly after Boulding arrived in Michigan, the Division of Social Sciences received a grant of $300,000 to support interdisciplinary research over a period of five years and Boulding was chosen as a member of the research planning committee. Activites to be supported included research on ethnology, economics, political behavior, human ecology and population, social organization and dynamics, individual behavior and development, and mathematical models in social theory.[38]

The University of Michigan had a strong tradition of interdisciplinary work in the social sciences and was included (along with the University of Chicago, Harvard, Stanford, and the University of North Carolina) in a Ford Foundation survey of the major programs in the behavioral sciences. This tradition is reflected in a 1931 seminar on the metropolitan community, taught by Professor R. D. McKenzie, who wrote that "an interdepartmental research seminar could provide a valuable service by bridging the gaps between related though separate social science disciplines." A number of interdepartmental programs grew out of this seminar. The Social Science Research Project was established in 1946, integrating graduate-student research with service to the local community. Two years later the Institute for Social Research was established, including the Survey Research Center and the Research Center for Group Dynamics. This tradition of integration and cross-fertilization was particularly attractive to Boulding. In 1952 he received an individual grant of $5,500 from Ford that, among other things, provided support for his interdisciplinary seminars as well as the initial efforts of the Systems Society. In addition, Boulding was a member of the foundation's Advisory Group on Economics and the Behavioral Sciences, established to determine how the Ford Foundation might contribute most effectively to the goals of economic development.[39]

Several of the economists in the advisory group were critical of the foundation's interdisciplinary focus, because they thought integrative efforts tended to remain pragmatic or amateurish. Nevertheless, there was widespread agreement among the entire group that the economic emphasis on rational choice was inadequate, leaving out critical issues of power and control. The foundation's aim was thus to promote a more dynamic economic analysis, and the advisory group sent out a report to social scientists throughout the country seeking their input. The consensus among respondents was that perspectives from other social sciences, particularly social psychology, might prove useful in extending the traditional boundaries of economic analysis and moving toward a more unified theory of human motivation and behavior. The foundation's ultimate goals included enhancing economic structures and procedures in order to sustain a balance between freedom and control, achieving a just distribution of wealth, and promoting peace, progress, and stability (defined as full employment).[40]

The most interesting comment among the replies to the advisory group's report came from Walter Rostow at the Massachusetts Institute of Technology, who wrote: "There is an issue of first importance which has been left out of the discussion; namely the formulation of a systematic alternative to the Marxist relationship between economic forces on the one hand and social and political forces on the other. I know of no major problem of history or contemporary life that does not confront the social sciences with this question." Clearly the climate of the Cold War had a profound impact on the evolution of social thought during this period, and it is worthwhile to consider how this context shaped Boulding's own concerns before examining the themes of his interdisciplinary seminars in greater detail.[41]

THE CHALLENGE OF COMMUNISM

Like most Americans during the postwar period, Boulding favored a market economy because he believed all other systems were coercive. His faith in the marketplace was based on his belief that it was characterized by reciprocity in the exchange of goods and services. He felt that communism led to the concentration of power in a one-firm state, replacing a "polylithic society in which many firms are integrated through the market mechanism, with a monolithic society in which the whole of economic life is organized in a single, integrated unit," resulting in an economic and political monopoly. He considered this monolithic character of communism to be its fatal weakness. For him, the market was a symbol of peace, characterized by principles of free exchange and compromise instead of coercion. In contrast, Marxism, like nationalism, embodied an ideology of conflict, and this basic motivational drive of hatred and envy reflected another fundamental defect in Boulding's eyes. While he acknowledged that the free market was subject to serious pathologies, "the Marxist solution seemed to have far too high a cost in terms of the loss of human freedom and the worship of violence to be acceptable."[42]

On the other hand, Boulding often commented that Marx's impact in the West had been largely beneficial, providing valuable social criticism and catalyzing significant economic changes. And he also noted the parallels between Marxism and Christianity. The importance of Marx, he said, "lies in the faith of which he is the prophet," sharing the same kind of structure as other Judaic faiths, with a "triumphal arch" at the end of a "one-way street," in contrast to the Eastern view of history as a cyclical process. He describes Marxism as a parody of Calvinism in its doctrine of freedom as cooperation with necessity, the "puritan fanaticism" of its followers, and its "escatology of revolutionary hope." However, its emphasis on negation as an essential aspect of the dialectical process leads to an irresponsible attitude toward historical reality and human lives. While he credits Marxism with the spread of education, science, and technology into previously stagnant societies, ultimately he thought it had betrayed its promise to the working class.[43]

Another problem for Boulding was that communism was a "movement by intellectuals to capture the political apparatus for the purpose of imposing an abstract view of the world on the concrete realities of society." Here again he warns against the perils of system building: "For minds which are intolerant of intellectual ambiguities, a total system like Marxism is very attractive." He saw it instead as a premature synthesis in social science and a dangerous simplification of social dynamics, with "an inadequate sociology of class, an inadequate anatomy of power, and an inadequate view of what it meant to be human," suggesting that Max Weber had achieved a much more successful integration than Marx. On the other hand, he applauded the Marxist emphasis on planning for the future, Engels's "leap from necessity into freedom," that he saw as one of most important ideas of the nineteenth century.[44]

Boulding characterized the difference between communism and capitalism as one between organizational and ecological growth patterns, contrasting the chicken, a "centrally planned economy," which follows an organizational growth pattern, with the ecosystem and its evolutionary pattern, reflected in free-enterprise economies. While the growth of knowledge would favor organizational patterns of growth in society, he thought that Marx had not taken sufficient account of the role of organizational factors in his critique of surplus value. By eliminating some of the illusions undermining its legitimate aims, Boulding hoped to foster a more realistic radicalism.[45]

Despite his critique of Marxism and communism, however, Boulding was outspoken against the intolerance of the McCarthy era, arguing that the university had an obligation to set an example in encouraging tolerance. In a letter to the editor of a campus publication he wrote: "The toleration of unorthodoxy, even of subversion, is not a luxury, it is a necessity for the continuing health of any society which cannot long survive if it is not continually challenged to re-examine and re-think its own basic beliefs." In a letter to Dean Odegaard, he wrote, "Anti-communism is cut from the same cloth as anti-Semitism; it is not a reasoned fear of a real danger, but a neurotic anxiety on which we project our own uncertainties and frustrations." He saw the intolerance of a few communists in the university as a sign of grave weakness, reflecting "a subconscious fear that perhaps the communists are right." In an open letter, "To the Communists," he wrote:

> On our side we have visited on you our secret fear and mistrust of ourselves and our society. We have been afraid of the prophetic criticism, and have persecuted the prophets like our fathers before us. On your side there has been pride and deceit, . . . you have rejected God. . . . You have believed that good can come out of violence. You have set up societies of monstrous cruelty. You have perverted science and have corrupted friendship. And now we are copying you in all these things. We have given lip service to God and denied his laws of love. We too have put our faith in violence, and have set up monstrous cruelties.[46]

Most troubling to Boulding was the extent to which he thought the United States had succumbed to Russian propaganda regarding the dependence of the American economy on the arms industry, motivating a life-long concern with conflict resolution and the economics of disarmament. For him, freedom was only possible outside of large organizations; if General Motors or the Pentagon absorbed the whole economy, we would essentially have a communist state. In his view, the case for capitalism was a case for smallness of scale. He pointed out the dangers of what he called military socialism, with the military-industrial complex rapidly becoming the "third largest socialist organization in the world" and the Defense Department emerging as a kind of shadow government, founded on the misguided belief that war was necessary for national survival.[47]

This view was caricatured in the *Report from Iron Mountain on the Possibility and Desirability of Peace,* allegedly written by a secret government study group, which concluded that although a permanent peace might be possible, it was probably not desirable. The report suggests that war serves indispensable economic, political, and sociological functions and is the "basic social system" to which other "secondary modes of social organization" must be subordinate. It was generally reputed to be a hoax, of which Boulding was actually considered a possible author. Purportedly, a copy of the report was given to Leonard Lewin by a member of the study group, urging him to publish it. Perhaps truer than truth, whether hoax or no, the report provides "penetrating insights into the system of the think-tank operation," evidenced in such institutions as the RAND Corporation and Herman Kahn's Hudson Institute. In his comments on the report, Irving Louis Horowitz echoes Boulding's concerns: "The extent to which a belief in the desirability and inevitability of 'the war system' is built into the operational conceptions of the Government is of deepest public concern."[48]

Boulding was particularly critical of the way in which important social decisions were being entrusted to the "amateur sociology of distinguished physicists," and felt that it was essential to develop a science of decisionmaking based on a better understanding of human behavior. He wrote a letter to Edward Teller, arguing despite his own temptation to feel hatred toward Teller himself for his hawkish influence on military policy, that we couldn't build a healthy national life on hatred and fear. The only way to remove the burden of fear from mankind was through a politics of forgiveness, of common humanity, and of creative conflict based on a willingness to discuss, to see the other fellow's point of view, and to strive together for a solution acceptable to both parties.[49]

TOWARD AN INTEGRATED THEORY OF SOCIAL INTERACTION

In light of this general orientation, it is instructive to trace the progression of topics that Boulding addressed in his interdisciplinary seminars at Michigan, beginning in the spring of 1950. His choice of topics clearly reflects issues of concern to the postwar world, as well as a convergence with the concerns of the Ford Foundation, anticipating lines of integration within both the behavioral sciences and general systems:

1949–1950: "Competition and Cooperation"
1950–1951: "Theory of the Individual"
1952–1953: "Growth Theory"
1953–1954: "Communication and Information Theory"
1955–1956: "Conflict Resolution"

He offered a seminar on economics and ethics in 1958 and another on general systems in 1963, but the development of the first five seminars most clearly reflects the evolution of his thinking with regard to GST. Foreshadowing the goals of the SGSR, he hoped to "bring to bear the methods, conceptual frameworks, and insights of a number of different fields in some fairly well-defined theoretical problem." Having found that many concepts and theorems that have been developed in one field have relevance to others, he hoped to help break down the barriers to communication between specialized disciplines.[50]

Boulding spent the fall of each year recruiting faculty participants for the spring seminar. Although he claims that the social scientists didn't really want to be integrated, he drew from a broad array of disciplines in both the natural and social sciences. In the first seminar on competition and cooperation, he began with a biological perspective, focusing on the field of ecology for a discussion of competitive and cooperative relationships among plants, animals, and their environment. Insights from sociology and social ecology were applied to the study of group interaction. Developments in cultural anthropology informed an examination of competitive and cooperative relationships in different cultures. Economic theory was articulated in relation to various forms of market interaction; and political science provided insights into interactions between different parties, factions, and nation-states. Drawing on psychology, they examined the role of competition and cooperation within the personality and between individuals, as well as the effect of competitive and cooperative environments on personality development. Laying the foundation for his next topic, Boulding's summary of the seminar concludes:

> Even when all false analogy has been discounted, there is something like a general theory of interaction which emerges from the comparative

> study of Biology, Sociology, Social Psychology, and Economics. . . . The search for a theory of "competition" as distinct from a theory of interaction in general does not seem to be very fruitful. . . . The form of interaction depends on what interacts. Hence a complete theory depends upon a theory of the "interactor," or the individual.[51]

The influence of population theory is apparent in his conviction that social phenomena can best be understood by examining them as systems of interacting populations; Boulding's sense of ecology was grounded in the universality of this concept of interacting systems: "Reality in its quantitative aspects must always be considered as a system of populations." Based on Vito Volterra's earlier work on the equilibrium size of populations, he wanted to develop a general theory of such interactions, in terms of the "equilibria and dynamics of populations," which was central to his conception of GST: "All sciences study societies, . . . systems of mutually interacting parts. Each science has its own universe of discourse bounded by its conventional atom and its own system of abstraction. All universes of discourse [however] have certain broad similarities." In exploring such similarities, Boulding was always looking for "general theories" of the individual, of interaction, of conflict, and so on; although such projects are no longer in vogue, his ideas on these themes have stimulated some important theoretical developments. He notes that the kind of study he proposed "seems to have no name but as it was first developed in the biological study known as ecology this name may as well be given to it, especially as sociologists have already appropriated the name for social phenomena, though often in a rather narrow geographical sense."[52]

Reflecting on the relationships among the various "universes of discourse," Boulding often described economics as the second-oldest science, citing Adam Smith's theoretical formulation in *The Wealth of Nations,* which was itself inspired by Newtonian mechanics. In turn, Darwin's theory of evolution was greatly influenced by the early economists; such concepts as equilibrium, nucleation, and even aspects of ecological theory were rooted in economic thought. Boulding identifies the concept of ecological interaction as the foundation of the evolutionary perspective, noting that economics itself was originally evolutionary, becoming increasingly quantitative and static with the contributions of Leon Walrus. Regarding other social sciences, his views on geography and history are particularly revealing: "Of all the disciplines, geography is the one that has caught the vision of the study of the earth as a total system, and it has strong claims to be the queen of the social sciences" in integrating perspectives from both social and natural sciences. Historians, on the other hand, are "terrified of anything that looks like a generalization."[53]

Drawing on this interactive view, the seminar on the individual began with a description of the individual as "a functioning aggregate, defined by a boundary between itself and the rest of the universe, capable of being described in terms of its structure and its behavior." Addressing such diverse examples as cells, bodies, ecosystems, firms, families, states, cultures, and languages, these various classes of "individuals" were then categorized in terms of their respective equilibrium processes and their ability to respond to changes in their environment, progressing from simple homeostatic processes to more complex processes of maximization and conscious response. Like biological individuals, which are characterized by adaptability and systematic changes in behavior, or "learning," at even the simplest levels, natural communities and social organizations might also be seen as self-regulating systems maintaining their individuality through similar processes of internal regulation.[54]

Based on distinctions between their respective levels of response, Boulding articulated his taxonomy of individuals as a framework for a comparative study of individuals and interactions across disciplines. This hierarchy of systems (see Table 8.1) is based on the level of complexity of the basic individual, with the aim of developing "a level of abstraction appropriate to each." His model of nine system levels was central to his understanding of general systems. Each level manifests characteristics of the levels below as well as incorporating new elements of behavior. Boulding often commented on the problem of applying methods that were appropriate to phenomena at the lower level to more complex levels of organization and behavior. At the level of the social system, for example, "knowledge of the system becomes an important part of the system itself."[55]

Informing this evolving taxonomy of levels of complexity, the growth seminar built on conceptions of individuals and processes of interaction from the first two seminars. Examining characteristic responses to changes in the environment, the seminar explored the nature of the equilibrium state for each type of individual, as well as such systemic changes as "growth and decay, learning and accretion, survival and evolutionary development." Beginning with the process of nucleation and growth in crystals, the seminar then considered the nature of growth in bacteria. Based on D'Arcy Thompson's work in *On Growth and Form,* they explored growth patterns and environmental response in the natural world. From the social-science perspective, they considered the meaning of growth in psychology, sociology, education, and economic development. They even considered the growth of buildings from the perspective of an architect. Boulding later remarked that this was the best of his interdisciplinary seminars.[56]

Building on themes from the seminar, Boulding's book *The Organizational Revolution* examined the growth of social organizations. He also wrote several papers in connection with this seminar, including "A Conceptual Framework for the Social Sciences," setting the stage for his seminar on information with the observation that "in human interaction . . . the environment to which an individual reacts is not merely an external but an internal, subjective environment." In addition, each individual becomes part of the external environment of others. He considered this typology of interacting individuals as a critical new direction of inquiry. Drawing on his model of homeostatic feedback (in Figure 8.1, p. 209), he suggests that cycles in economic and social life result from insufficiently sensitive homeostatic mechanisms, with a consequent lag between the receptor and the effector, further fueling his critique of the assumption of static equilibrium in economic theory.[57]

Table 8.1. Kenneth Boulding's Nine System Levels

Level	*Description*	*Characteristics*
Frameworks	Static structures	Anatomical relationships
Clockworks	Simple dynamic systems	Predetermined motions can be modeled as systems of differential equations
Thermostats	Cybernetic control mechanisms	Incorporate transmission and interpretation of information in operation of the system
Open systems	Self-maintaining	Phenomena of life; capacity for learning
Plants	Growth systems	Division of labor; equifinality
Animals	Aware systems	Mobility; teleology
Humans	Self-conscious systems	Language/symbolism
Symbolic systems	Systems of meaning	Products of human consciousness
Social systems	Relationships of power, exchange, and cooperation	Socially constructed; subject to conscious design

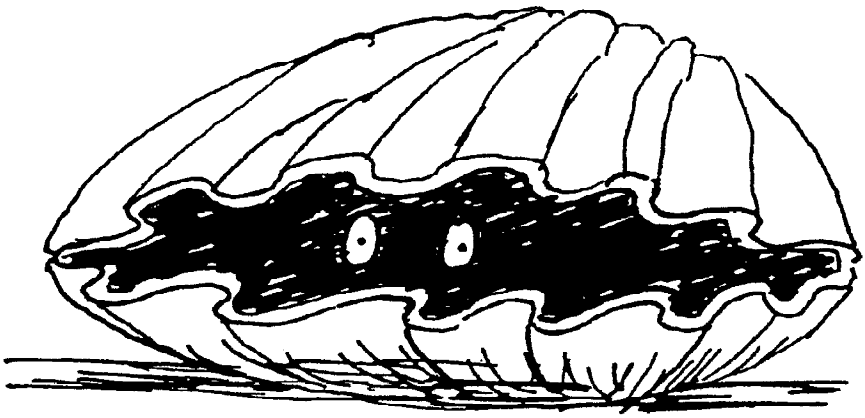
Boulding first contacted Bertalanffy in November 1953, after reading his article "The Philosophy of Science in Scientific Education," which described his conception of GST. In his letter Boulding asked whether Bertalanffy thought the time might be ripe for the formation of a society to promote this idea. Bertalanffy agreed that there was a need for an integration of systems concepts and approaches, sending Boulding a copy of his proposal for an institute for systems research, which Aldous Huxley had encouraged him to send to the Ford Foundation. Boulding and Bertalanffy then drafted a letter to be sent out to natural and social scientists who might have an interest in forming a society devoted to the general study of systems. One of these was sent to Anatol Rapoport, who responded with interest in June 1954. That spring, as the plans for the opening of CASBS were becoming firm, Boulding contacted Ralph Tyler to recommend Bertalanffy as one of the invited fellows.[58]

The spring seminar that year focused on communication and information, beginning with the emergence of information as a basic concept in physics and exploring related topics in thermodynamics, neurophysiology, psychology, linguistics, journalism, and epistemology. Describing communication as "the most important practical problem of the age," Boulding emphasized the need for a better understanding of the nature of information and its role in organization. This seminar fostered the synthesis that would emerge after Boulding's year at CASBS in *The Image: The Place of Knowledge in Organisms and Organizations,* published in 1956, which he later considered his most influential book. He dictated *The Image* in two weeks as he was packing to return to Ann Arbor, providing an excellent overview of his perspective on systems theory. Three years after he wrote it, George Miller, Eugene Galanter, and Karl Pribram happened upon it in the CASBS library and spent their fellowship year developing its ideas into their *Plans and the Structure of Behavior,* which contributed significantly to the study of cognition.[59]

Boulding's 1955 article "Notes on the Information Concept" summarizes themes from the seminar, which he developed further in the workshop on general systems at CASBS. Citing Ross Ashby's work, he clarifies the distinction between information and matter-energy. Referring to his cybernetic model, he then argues that organization cannot exist without communication. Informing his view of evolution is the idea that, while matter and energy can be neither created nor destroyed, information is cumulative and capable of continual growth and expansion. Drawing on Claude Shannon's articulation of information theory, Boulding draws some interesting conclusions for human communication, suggesting that redundancy is necessary given the amount of noise. It is, he says, "only by constant reiteration in many different formulations that ideas ever really get across from one mind to another." He also notes significant implications for epistemology and ethics in the information concept.[60]

On the other hand, Boulding argues that information theory alone cannot account for semantic content or meaning. He describes information theory as "one of the most important intellectual developments of his lifetime," although it is necessary to get beyond the "'Bell Telephone' information concept of Shannon and Weaver." In both the information seminar and *The Image,* he explored the relationship between information and knowledge, drawing on his earlier work in capital theory to define knowledge as "stock" and information as "flow." From this perspective, he developed his concept of a homeostatic mental structure (the image) that shapes the individual's perception of the world and his/her place in it. Because this mental structure would tend to resist change, he describes the reorganization of such images as an evolutionary process. Because they are important determinants of human behavior, Boulding sought to understand the dynamic processes involved in the maintenance and evolution of such images. This would become a major focus in most of his later work, underlying his continuing interest in semantics and communication. Along with Rapoport, he joined the editorial board of *ETC: A Review of General Semantics,* the journal for the Society of General Semantics, reflecting a common concern with the role of information and communication in the maintenance of organization in social systems.[61]

The role of the image becomes increasingly important at higher, more complex levels of organization. At the human level, Boulding describes the image as a kind of mental filter, based on the individual's past experience, which shapes the perception of any new signals. Echoing Bertalanffy, in opposition to the behaviorist model, he thought that individual behavior was determined not by an automatic response to an immediate stimulus, but by the significance of the stimulus as interpreted through the lens of the image, as a kind of active internal organizing principle. As he said, "Between the stimulus and the response is the image," illustrated in his typical whimsical style in Figure 8.2. The image was his term for the cognitive structure of knowledge, which he saw as an essential organizing force in society: "The social system tends to be dominated by images, . . . especially of the future, which act cybernetically, constantly guided by perceived divergences between the real and the ideal."[62]



The Intervening Variable
Thinks his life will be more stable,
If his feature he ensconces
In Stimuluses and Responses.[63]

Figure 8.2. The Intervening Variable

At higher levels of organization, the image becomes an increasingly important part of any theoretical model. Just as celestial mechanics is not appropriate to stochastic (probabilistic) systems with changing parameters, it is even less applicable to systems with information as an essential component, which introduces even greater uncertainty into the system: "Systems involving information, know-how, knowledge and learning have strong elements of indeterminacy in them." This is particularly true with regard to evolutionary systems; since information is the only thing capable of evolution, it provides the key to evolutionary structure. Referring to Hans Driesch's work on equifinality (the process of growth toward a specific goal), Boulding notes that genes are capable of organizing matter into patterned structures through the transfer of information, although despite the efforts of Lamarkian biologists to prove otherwise, they are generally poor learners.[64]

This observation, however, provides the key to his distinction between biological and social organizations in terms of the nature of the images determining their evolution: "Without self-consciousness, the dynamics of any evolutionary system is one of random mutation and selection. With self-consciousness, the evolutionary process becomes at least in part teleological, directed by an image of the future in the minds of active participants who are capable of affecting the system." Boulding insisted that his evolutionary vision was "unfriendly to romantic nature worship," the view that the human race and its artifacts are not part of nature. He identifies invention as the process of social mutation, equating his concept of the "social genosphere" with Pierre Teilhard de Chardin's notion of the noosphere. He suggests that the conception of society as an ecological system is "not merely an analogy . . . the genes of the social organism are ideas in the minds of men," anticipating Richard Dawkin's concept of the "meme." The information structure of these social genotypes is "capable of creating a teleological process to produce the phenotype of social organizations." The difference between biological and social organizations is the "much greater importance of decisions in social systems in determining the future."[65]

Boulding acknowledges the problems with biological analogy in social thought, as in organismic conceptions of the state, with the king or ruling elite as the head of the body, or in social Darwinian formulations of the competitive struggle for survival, noting that a critique of analogy is essential. In his view, social Darwinism adopted a "profoundly erroneous view of the nature of evolution." Referring to the work of Peter Kropotkin and W. C. Allee, Boulding argues that struggle is a minor aspect of ecological interaction. He critizes the more recent sociobiological synthesis for its emphasis on "biogenetics" over "noogenetics": "Once human valuations appear on the evolutionary scene, a whole new selective process appears in the world and the evolutionary process is markedly changed by it." In place of the struggle for survival, reflected in the competitive dynamics of the marketplace, he suggests that a more accurate and viable model of social evolution would emphasize "modesty, adaptability, variety, and complexity." In his typically expansive and optimistic style, he outlines the possibilities for the future as he sees it: "Only by understanding what is nonrandom in history can man hope to move from the slavery of evolution to the freedom of teleology. Only as we learn the real processes of society can we mold the future toward our present ideals." Thus the image of the future is a crucial factor in social evolution. The same is true of images of the past, accounting for the significant role of historians in shaping the shared images and collective identity of a society. Boulding's own view of the ideal future was "a more integrated society with fewer people excluded from its benefits and responsibilities."[66]

For Boulding, a serious problem with economic theory was its neglect of the critical role of information and perception in economic behavior: "From Adam Smith to Pareto it has been celestial mechanics applied to earthly things." He describes the development of such fields as management science, operations research, and decision theory as an attempt to address this issue, emerging initially out of economics and then establishing themselves as independent disciplines. Based on the idea that individuals act on the basis of what they think is best at the time, decision theory emerged from efforts to model such subjective perceptions mathematically. Management science evolved techniques for identifying the best out of a set of possible choices, using linear and nonlinear programming to arrive at the best possible options given an initially defined agenda of choice. Boulding notes that such techniques confer an illusion of certainty, leading to premature closure in situations with a significant degree of uncertainty that require greater flexibility. And, of course, values and assumptions are implicit in these models, in the choice of variables and the definition of their mutual relationships, not to mention the determination of ends to be maximized. While these techniques may have resulted in decisions that were beneficial to the decisionmakers, it was usually at some cost to society at large. Nevertheless, they ultimately prompted efforts to include all stakeholders—everyone who would be affected by a decision—in the decision-making process, among more progressively minded management theorists, many of whom were inspired by Boulding's work.[67]

Repeating a common theme, Boulding suggests that organizational hierarchies tend to distort information, and that this defect in our information systems has profound effects on our ability to make reasoned decisions. Since the success of individuals within a hierarchy depends on their ability to please their superiors, they will tend to pass on information that they think will please those above them; thus information passing through many layers of a hierarchy will be significantly altered in transit: "Top decision-makers are apt to be insulated from the real world and receive only that information which confirms their previously established images." This problem relates to what Boulding called "suboptimization," the tendency among systems engineers and designers to spend their time finding the very best way of doing something that shouldn't be done at all, because they fail to consider the larger context, often with disastrous consequences.[68]

Anticipating current perspectives on the social construction of knowledge, Boulding suggested that society and the image mutually create each other, and he drew some fairly radical conclusions concerning the relationship between fact and value from this conception: "Even the objectivity of science is reduced to a matter of probability and payoffs; the whole concept of fact really disappears, . . . [and the] interpretation of messages as facts depends upon the value system of the observer." Further, he says, "there are no such thing as 'facts,' only messages filtered through a changeable value system." The following verses from "The Feather River Anthology," originally published in 1966, reinforce the idea in typical Boulding style:

> To sift the value from the fact
> Requires a monumental tact
> For values, everybody knows,
> Have easy-to-be-stepped-on toes,
> And facts so often take a notion
> To clothe themselves in wild emotion.[69]

Boulding was also concerned with the relationship between knowledge and power. In a paper on the "Political Implications of General Systems Research," he describes the social system as a symbolic system with images as the raw material. A handout for the information seminar quoted Warren Weaver as saying that information was "a measure of one's freedom of choice," from which Boulding concluded that if alternative views were either ignored or suppressed, "our information, and hence our capacity for rational thought and action, [would be] reduced." In his notes on the image, he suggests that elites tend to cut themselves off from information sources, leading to his preference for organizational pluralism, maintaining many centers of power in order to avoid the problem of one-way power and communication, which is ultimately coercive. Building on his insights regarding the means of attaining power in organizations, he suggests that "the images that are useful in gaining power are seldom useful in exercising it wisely or keeping it."[70]

Boulding's understanding of the relationship between knowledge and power is couched in an analysis of different subcultures and their respective universes of discourse. He describes science as merely one subculture among many, and the scientific method as merely one of many methods whereby images change and develop, anticipating recent currents of thought on the objectivity of science: "We delude ourselves if we think that the self-perpetuation of images through the apostolic succession of authority is unknown to science. The acid of science which has eaten away so many ancient images now is seen to turn on the image of science itself." He suggests that all subcultures tend to develop warped images when cut off from others, a problem that could be corrected through interpenetration, reflecting his optimistic belief that images would tend to converge through conversation and that the breakdown of isolation between subcultures would lead to rapid change.[71]

The study of images, which he dubbed "eiconics," was "more friendly to radical empiricism and phenomenology. It is most compatible with a catholic metaphysical viewpoint which sees validity in many different modes and processes whereby images are changed . . . [and it] makes no sharp distinction between fact and value, but sees the image as part of an organic process of growth and evolution." Boulding traces the roots of his conception of the image to the sociology of knowledge as developed by such figures as Marx, Weber, and Mannheim. Echoing Bertalanffy, he describes eiconics as explicitly antibehaviorist, bearing more resemblance to the pragmatism of William James, gestalt psychology, and the "New Look" in perception theory. He draws on the value theory and cultural relativism of emerging schools in anthropology, the social psychology of George Mead, and the group dynamics of Kurt Lewin. He defines truth in operational terms as a measure of survival value, citing the influence of Alfred North Whitehead. On the other hand, he rejects C. G. Jung's concept of archetypes because they make the image too independent. He identifies his approach to the integration of knowledge with such programs as the Encyclopedia of Unified Science at Chicago, the Institute of Management Science at Pitts, and the Social Relations Department at Harvard. More dramatically, he describes his project as an attempt at "restructuring the universe of knowledge," which would have to survive "in an underworld . . . of deviant professors, gifted amateurs, and moderate crackpots," until such time as it might someday be reflected in the organization of the universities. Like Bertalanffy, he sought to "bring the actor into the act" in a theoretical framework that could address the limitations of mechanism "without falling into vitalism."[72]

In *The Meaning of the Twentieth Century*, Boulding extends this conception of the image into an analysis of ideology, which he describes as the "social institution which is the guardian of identity." Accordingly, an image of the world becomes an ideology if it creates a role that is highly valued:

> A man, for instance, who has built his whole life and identity around a particular ideology will be most unwilling to change the image of the world which his ideology implies, for he seemingly cannot change his image without denying his own identity as a person. . . . His system of values . . . filter[s] out all the messages which are contradictory to his image of his own identity.

To qualify as ideology, such images of the world must create a sense of drama, as well as an interpretation of history, that gives the individual a meaningful sense of identity. Boulding suggests, further, that the ability of an ideology to organize society depends upon the optimistic or pessimistic quality of its images and whether or not it holds that the future can be intentionally directed through human activity.[73]

In his 1958 seminar on economics and ethics, addressing the problem of economics in a democratic society, Boulding inquired further into the nature of the self. The seminar drew on the work of John Dewey and Erich Fromm in conceiving democracy as the form of society best able to foster the fulfillment of the "human" potential of its citizens. This view was reinforced by psychoanalytic theory, in its understanding of human nature as a product of society, providing what Boulding saw as the best argument for democracy, defined in terms of acceptance of responsibility and participation in decisionmaking.[74]

In a letter to Lyman Bryson that same year, Boulding stressed the significance of "systems knowledge," especially of social systems, for policy decisions. He describes this development as "the most important intellectual movement of our day." Summarizing his previous work, he discusses the significance of the rise of large-scale organizations, the reasons for this organizational revolution, and the nature of responsible decisionmaking in such organizations. In particular, he is concerned with decisions as "functions of the image of the decider," and the way in which these images are built up by feedback processes in information systems, with their inherent danger of corruption. Given the complexity of social systems and the difficulty of obtaining accurate information, he emphasizes the importance of organizing theories, giving the Keynesian revolution as an example. He mentions cybernetics, open-system theory, information theory, along with the systematic collection of data in survey research, market research, public-opinion polling, content analysis, and the increasing sophistication of mathematical modeling techniques as examples of current theoretical and methodological developments that might enhance the general level of understanding and thus the possibility of directing these organizations toward agreed-upon ends. A retrospective article, written in 1987, reflects Boulding's perception of the role of GST in addressing these issues:

> Is there then a potential for modifying ideologies to make them more benign? A critical question here is whether the institutions of society permit the kind of feedback, especially in positions of power, which can correct mistakes. . . . If our decisions are made in terms of partial

> systems and reality is a total system, then we are in for trouble. . . . How we perceive and handle both the internal identity and coherence, and also the interdependence and interactions of different systems, is an extremely important question for human life and society.

In *The World as a Total System,* published in 1985, he offers an in-depth analysis of the implications of the increasingly interconnected nature of the social, economic, political, and ecological systems of the world.[75]

Boulding was a visiting professor at the University College of the West Indies in Jamaica in 1959–1960, where he offered a seminar in "Theoretical Systems and Practical Decisions." In his prospectus for the seminar, he writes: "As an economist I am interested in economic policy, in the theory of the firm, in the theory of organizations in general, and in the general theory of behavior and decision making. I am much interested in the contribution of other sciences such as biology to the theoretical structure of the social sciences." In the seminar he addressed the impact of theoretical systems on decisionmaking, especially at the policy level. All decisions are made in light of some "view of the universe," even though this may be unformulated or even unconscious. The main purpose of the seminar was to bring together theoreticians and practical policymakers for a mutual exchange of information. Building on his model of the nine system levels, the seminar provided an overview of the kinds of choices faced by different systems. During his year in Jamaica, he also wrote *Conflict and Defense,* his major contribution to the peace research movement, in which he began to develop his conception of the three major organizing systems in society that he designated as the threat system, the exchange system, and the integrative system.[76]

CONFLICT RESOLUTION AND THE INTEGRATIVE CONCEPT

The concept of the image was central to the seminar on conflict resolution that Boulding gave when he returned to Michigan after his sojourn at CASBS. The purpose of the seminar was "to integrate the work of model builders and theoreticians with the practical experience of technicians who deal with problems in conflict resolution . . . [and] to foster the development of new models for the resolution of conflict." It explored the nature of conflict at various levels of organization, as well as different classes of conflict processes, which were then developed more systematically in *Conflict and Defense*. Ralph Gerard, then in residence at Ann Arbor, gave one of the presentations, dealing with "cooperation and conflict as modes of integration." Like previous seminars, it drew on insights from the biological sciences, examining conflict in the animal world, as well as further developing the relationship and critical distinctions between organismic and systemic patterns of organization. One session focused on the military establishment as a social system, comparing its hierarchies, social strata, power dynamics, and channels of command with civilian society. A general conclusion of the seminar was that the resolution of conflict might be characterized alternatively by avoidance, domination, or convergence of ends.[77]

Lewis Richardson's work on interaction processes was particularly influential. His son Stephen had been in residence at CASBS and had brought microfilm copies of his father's work, previously unpublished, that became a guiding inspiration for Boulding's work in peace research. Building on Richardson's mathematical models, he explored the relationship between friendly and hostile elements in conflict. One of his more innovative contributions was to examine these elements using an epidemiological model, in terms of the relative contagiousness of friendliness and hostility, a common theme in his later work: "There is a curious tendency . . . for enemies to become more like each other, simply because each shares a culture of enmity that has profound effects on all the other aspects of the culture. . . . Cultures of enmity and violence are more likely to spread and become characteristic of the whole human race than are cultures of tolerance and fraternity."[78]

This perception informed the seminar's discussion of developments in game theory, drawing on Rapoport's argument in connection with the "Prisoner's Dilemma" that the short-run rationality common in military strategy usually resulted in everyone being worse off. Game theoretical models included an analysis of the opponent's likely choices, in contrast with Richardson's relatively mechanical analysis of reaction processes. Acknowledging that the interacting population model was too static and failed to account for the unique history of each specific conflict in its equilibrium equations, Boulding noted that "in spite of the absence of any eiconic considerations, it is extraordinarily useful in interpreting certain sets of historical events." Still, he thought game theory, especially models of non–zero-sum games, might offer greater possibilities for resolution of conflicts that would emphasize the convergence of ends over dominance or avoidance.[79]

The seminar also considered analytical models from economics and psychology. Of particular interest for Boulding was the theory of oligopoly, or competition among the few, as it applied to international affairs. From the psychological perspective, they drew on Kurt Lewin's and Neal Miller's work on field theory in relation to conflict within the individual, exploring factors influencing tendencies toward approach or avoidance, the roots of hostility, and the function of symbols in relation to attitudes about conflict. Building on Freudian analysis, they looked at the relationship between internal hostility and the predisposition to perceive hostility in others. Acknowledging that the resolution of ethical conflicts was essential to the process of conflict resolution, Boulding noted that "it also involves 'theology,' a view of history, of the potentialities of man and the sources of right action."[80]

Developing these themes in *Conflict and Defense,* Boulding explores the nature of conflict from an ecological perspective and incorporates an analysis of conflicts between individuals and organizations dealing with such issues as autonomy and socialization. His analysis of conflicts between ideologies is particularly insightful. In a section on "The Structure of Ideologies," he discusses the basic structural similarity of seven major ideologies, including liberal and orthodox Christianity, liberal and orthodox Marxism, liberal and fascist nationalism, and what he called worldliness, in terms of twelve categories: (1) interpretation of history, (2) image of the future, (3) nature of ideal society, (4) nature of ultimate reality, (5) nature of man, (6) nature of evil, (7) form of worship, (8) sacramental dogma, (9) emotional drive, (10) theory of value, (11) theory of social organization, and (12) characteristic form of society.[81]

For Boulding, discussion and convergence constitute the essence of the democratic process and are essential to the creative resolution of conflict, which depends upon the ability to “widen the horizon and perceive a new gestalt.” He writes: “The moral, ideological and affectional matrix of conflicts is of great importance in determining their course: adaptable value systems, ‘democratic’ ideology, and internally strong and well adjusted loving individuals make for creativity in conflict.” The role of communication was an essential element in Boulding’s approach to peace research, and he sought to develop theoretical models of stable peace that accounted for this role, with the aim of “transforming war into discussion.” Responsible decisionmaking, which he saw as the key concept of political theory, depends upon improving channels of communication at all levels of society. His proposal for the initiation of a journal of conflict resolution discussed the need to incorporate behavioral-science research into the study of peace, which had traditionally been confined within the disciplines of history and political science.[82]

Given his concern with the critical role of communication, Boulding lamented the secrecy that characterized so much of international policy. He even suggested a United Nations spying organization to address this issue. Echoing his earlier discussions of the distortion of information in hierarchies, he believed that so-called intelligence organizations passed on inaccurate information, and that it was “precisely these defects in the information system which [made] the probability of war so high.” To him, secrecy was the greatest enemy of science and of peace. He saw critical decisions being made more on the basis of “heroic attitudes, death wishes and the whole panoply of political paranoia” than on the basis of informed discussion. Boulding thought that a “Copernican” analysis of the international system as a whole, rather than a foreign-policy approach from the perspective of a particular nation, would provide a greater foundation for lasting peace.[83]

Of course, such analysis would require an understanding of the images and values underlying human behavior: “It is because of the symbolic nature of the image of man that conflicts in the human world are so much more complex than conflict in the animal kingdom, where images are built up only by signs and hence conflict is always face to face.” Defining behavior as “movement toward the most highly valued part of the total image,” Boulding sought to develop greater insight into the value dimension of the image. While biological factors reinforce values conducive to survival, the symbolic element in human values transcends these biological origins, often reinforcing behavior that threatens the survival of the human species as a whole. Of particular concern to Boulding was the tendency toward simplifying stereotypes underlying the ideological aspect of conflicts. Therefore he considered greater tolerance for complexity and ambiguity as essential in efforts to resolve such conflicts.[84]

In 1964 Boulding wrote, "My theoretical interests these days are moving toward what I am calling the integrative system," and of course he was also interested in how the processes of communication helped to build that system. He identified coercion, exchange, and integration as three major forces active in society, which he often referred to as "Police," "Profit," and "Preachment," and he considered integrative power the most important, responsible for the difference between destructive and constructive conflicts. His conception of the integrative system included such things as community, status, identity, legitimacy, love, respect, and affection. In their emphasis on community and connection, the integrative forces provide an essential counterbalance to the primarily selfish orientation of the marketplace:

> There is a danger that in a predominantly commercial society people will take economic behavior as the measure of all things and will confine their relationships to those that can be conducted on the level of the commercial abstractions. To do this is to lose almost all richness and purpose in human life. If the market is to be a stable and fruitful institution in society, it must be hedged around with other institutions of a non-market character—the home and the school and the church. For here and only here can the motive of responsibility develop. It is only as we ourselves are loved . . . that we gain the capacity to love.

In connection with the integrative function, Boulding suggests that values might be evaluated in terms of whether they serve entropic or antientropic functions in society, and he saw love as the most antientropic of all human relationships. In *The Image* he writes, "We still await the symbolic image which will unite us all," although at the same time he was "suspicious of the man with a blueprint," reinforcing his often-repeated plea for humility.[85]

The integrative function, as Boulding defines it, also contains a negative aspect, which includes such phenomena as alienation, exclusion, malevolence, and hatred. Similarly, there are positive dimensions to the coercive function, in agreed-upon systems of laws, for example. Furthermore, integrative processes are often allied with threat systems for legitimization. To a certain extent, Boulding suggests that these three forces can be identified with the disciplines of political science, economics, and sociology, although none of them can be understood in isolation. He considers issues of legitimacy, part of the integrative function, as central to both threat and exchange systems.[86]

This general orientation is apparent even in his earlier work. In *The Organizational Revolution,* for example, he writes: "Organizations . . . have to deal with the problem of consent—a concept which is not found . . . at the mechanical or organic levels." Unlike parts in a machine or organism, human participation in social organizations is voluntary. Thus the survival of the organization is dependent upon the willingness of the "constituent persons" to serve its ends. Boulding then suggests that there are several ways in which this willingness might be achieved. Individuals might identify with the purpose of the organization; their willingness might be obtained through economic means; or they might be coerced into serving these ends. However, he points out that "there is some threshold of unwillingness below which no amount of coercive power can force individuals to contribute."[87]

Boulding's concern with integrative forces was related to his theory of history. He was strongly opposed to the dialectical view of history as the struggle of "us" against "them," in which conflict is understood as the primary driving force in historical evolution. He preferred a developmental or evolutionary model in which dialectical processes are an important factor, but subordinate to the more integrative processes: "It is in societies where the prevailing ideologies are nondialectical—stressing community, agreement, orderliness, courtesy and love—that the dialectical processes themselves are likely to be most fruitful." He wrote *A Primer on Social Dynamics: History as Dialectics and Development* after returning from a year in Japan as a visiting professor at the International Christian University in 1963–1964, where most of his students were Marxists. The book was explicitly polemical, directed against the dialectical philosophy, which he defined as "all those ideologies which regard conflict as the essential process in development and therefore tend to put a high intrinsic value on conflict, struggle, war, and revolution," thus reinforcing the kind of heroic attitudes that foster violence: "A dialectical philosophy which stresses victory rather than problem solving, beating down the enemy rather than cooperating with him (and which therefore tends to justify and excuse the immoral behavior which dialectical processes always produce), is likely to intensify the dialectical processes themselves to the point where they will become damaging to all parties, and unfriendly to human welfare and development." Boulding acknowledged the moral strength of Marxism in its sympathy with the oppressed: "Marx was a towering figure with a prophetic moral challenge which demands a response of some kind." However, he hoped to foster the development of a theory of social dynamics that would not justify the kind of disastrous course that characterized actions based on Marxist theory.[88]

Boulding sought to overcome the tendency to dichotomize the world that he saw in the dialectical tradition. He pointed out that the United States was equally at fault in framing Cold War politics in dialectical terms. Instead, he encouraged dialogue over confrontation, which would require all parties to consider "unfamiliar sources of information and new points of view." His *Primer on Social Dynamics* included an extensive discussion of labor issues, arguing perhaps naively that dialectical elements were minor in disputes between labor and management, which he saw as "a positive sum game in which both parties benefit." He admitted that there might be dialectical elements in determining the terms of the bargain, but suggested that it was "often the weak who have the greater bargaining power, simply because the strong cannot afford to destroy the exchange relationship by pushing them to the wall." Comparing the Industrial Workers of the World with the American Federation of Labor, he suggested that the former set itself up for failure in viewing the industrial relationship in uncompromisingly adversarial terms. The latter was much more successful because it pushed for the best bargain it could get, emphasizing coexistence rather than war. At the same time, Boulding conceded that the development of modern technology gave established centers of authority a considerable advantage, and that it was "not easy to persuade the powerful to relinquish power." This issue, of course, is at the heart of debates about the social and political implications of systems models. Do such models simply facilitate greater social control and contribute to the power of established authority, or by encouraging a broader global view, might they offer insights into the possibility for more truly participatory forms of social organization?[89]

CONCLUSION: SYSTEMS THEORY AND THE ABUSE OF POWER

Although Boulding's views on the abuse of power might seem somewhat inconsistent, his recognition of the ambiguity and complexity of social systems, with the critical addition of the value component of knowledge and behavior, is perhaps one of his most important contributions to the systems view. His constant appeals to humility, while couched in somewhat moralistic terms, might be seen as anticipating more recent critiques of metanarratives that ignore the complexity and uniqueness of specific situations, critiques that are justifiably aimed at many applications of systems models. In his discussion of the different systems levels, Boulding demonstrates his concern with the diversity of systems and the determination of "appropriate epistemology." And he acknowledges that "unless the more general systems give guidance to the more special, local, and peculiar systems, they may not be very useful in actual decision making."[90]

Boulding distinguishes between two levels of systems analysis, which he refers to as "special" general systems and "general" general systems. He describes the first as primarily concerned with mathematical models and computer similations, which are heavily dependent upon the values and assumptions built into the models. The second, reflecting Boulding's own concerns as well as his perception of the original aims of SGSR, entails a more philosophical orientation and incorporates an examination of such values and assumptions in its analysis. In his presidential address to the SGSR in 1958, Boulding expressed his concern about the potential impact of the tools of systems analysis in shifting and concentrating the locus of political power and influence, pointing out the critical relationship between access to knowledge and power. Reflecting on the evolution of the general-systems concept in 1984, he wrote:

> Even within the general movement itself, however, I worry about a certain potential for trouble. . . . I would worry if special general systems moved too much in the direction of deterministic modeling and projection. One thing that has to be included in general systems is chaos—that is, the principle that everything is not systematic. . . . This is much more dangerous in the Pentagon, . . . corporate management, or government. Unless general systems recognizes the profound indeterminacy of evolutionary and especially of social systems, a deterministic view of these systems is apt to lead into delusions of certainty about the future

> which can be quite disastrous, and can lead to a neglect of adaptability, tentativeness, and that constant willingness to revise images, which are necessities of survival in an uncertain world.[91]

In her biography, Kerman portrays Boulding as working throughout his life toward a conception of wholeness that could balance diversity and contain polarities while still leaving room for individual growth and variety. He was clearly aware of the dangers of manipulation inherent in the development of large-scale social organizations: "I am not interested in feeling free; I am interested in being free. This may seem like a subtle distinction, but it can make all the difference between a society of free men and a nightmare of manipulation and public relations." He was concerned that the development of the social and behavioral sciences could easily play into the hands of the manipulators, warning that the social sciences might unleash power even more terrible than that released by the development of the atomic bomb, in its potential power to control "the minds and actions of men, both individually and in the mass." He was skeptical of elite power structures, which, even when devoted to apparently noble causes, have in the past always led to abuses of power.[92]

Addressing the implications of systems concepts for democratic theory, Boulding observed that political decisionmaking had previously been based on more casual and empirical knowledge. With the rise of more sophisticated social theoretical systems, he feared that the responsibility for decisionmaking might increasingly be transferred from lawyers, politicians, and businessmen to operations researchers. In either case, of course, decisionmaking power is generally limited to an elite few. In the earlier model, however, power was at least distributed among a more diverse group and based to a greater extent on "folk knowledge," personal experience, and common sense. He suggested that general systems might even try to incorporate such knowledge. More importantly, he argued that knowledge that does not take into account a multiplicity of views is inadequate. "It is hardly too much to say that if the world is destroyed it will be because decision makers lacked a sense of the general system of the world and only saw things from their own perspective." Reflecting his commitment to democracy, he asks, "How do 'the people' control the specialist? This problem has become acute in atomic energy. Democratic theory is based on the assumption that the kind of knowledge required for government is not scarce. Are we doomed to go back to a new Middle Ages, with Science as the Church and the Military as the King?"[93]

Boulding argues that only the "growing self-consciousness of science itself as a social system can enable us to avoid the impending catastrophe." A recurring theme in his work is the necessity for continual reexamination of fundamental assumptions and beliefs at every level of organization, demonstrating an unusually high level of self-awareness and reflexivity. In 1961 he wrote, "I have been disturbed for some time by the fact that it seems to be nobody's business to study the university as an institution." When he was a member of the advisory group for the Ford Foundation's Program on Economics and the Behavioral Sciences, Boulding suggested that the group address itself as a research project. This element of self-examination is an essential aspect of his contribution to the systems view. The recursive nature of this task is illustrated in classical Boulding style in this excerpt from "Human History in a Nutshell":

So man, with Science now apprised
Becomes Post, and Post-Post-Civilized.
No longer tied to horse or ox,
Or creed or culture orthodox,
Man, with his lustful eyes agleam
Breaks into coal, and oil, and steam,
Electric Power, and Nuclear Fission,
With Fusion as his latest mission.
Now that he has the power to man it,
He rips the guts from out his planet.

If there's an answer, then its basis
Must lie in Higher Homeostasis,
For evolution will not come
To simple equilibrium.
So Man, as critic and creator
Must regulate his regulator,
And even take a higher station
To regulate his regulation.

These theorems never quite assume
Just who is regulating whom,
And so there may be sharp debate
On who, or what, will regulate,
But Homeostasis there must be,
Of third, or fourth, or fifth degree,
Bringing, beyond all these degrees,
Man to his senses or his knees.[94]

It is the reiterative nature of this cybernetic process that underlies Boulding's faith in the possibility of human learning and the potential for continual self-transcendence in the evolution of society. The tension between expert knowledge and the democratic ideal continues to escalate as the world becomes increasingly interdependent, raising difficult issues of incompatability between different cultural values. Boulding's insights on the importance of pluralism and diversity, along with his emphasis on the importance of dialogue, have inspired some creative theoretical analysis, as well as some innovative practical approaches to addressing these issues, which have confirmed my own belief in the progressive potential of systems thinking.

A couple of particularly relevant examples can be found in the work of Boulding's students. In "A Case for Methodological Pluralism," Richard Norgaard discusses the relationship between the methodologies of economics and ecology, acknowledging his debt to Boulding. He suggests that economics has generally limited itself to a fairly monolithic econometric model, while the field of ecology has drawn from a number of different methodologies, including both mathematical modeling in population studies and fieldwork in more empirically oriented ecosystem studies. A second article, "Sustainability and the Scientist's Burden," coauthored with Sharad Lélé, discusses the difficulty of establishing accurate measures of such a value-laden concept as "sustainability," and the resulting need for participation and input from local dwellers in particular areas in determining its meaning in that context.[95]

Another student of Boulding's and former president of both the American Society for Cybernetics and the SGSR, William Reckmeyer, has drawn on the work of Chris Argyris and Donald Schon, from the systems-dynamics tradition, in articulating a systems approach to management and leadership. Echoing Boulding's concern with the relationship between organizational structure and the kinds of behavior that are nurtured and rewarded within that structure, Reckmeyer explores cultural phenomena, including beliefs about people, organizational values, and defensive patterns, in relation to work roles and lines of authority and accountability. He then distinguishes between single-loop and double-loop learning processes based on whether or not organizational goals are rigid or flexible, and whether or not they are open to discussion. The first model results in behavior characterized by defensiveness, competitiveness, and blaming, while the second involves participants as agents of change and fosters trust, testing of views, and increased personal responsibility. He describes his work as centering on "collaborative strategies to effect lasting systemic changes in problematic organizational, social, and public policy settings."[96]

A similar orientation can be seen in Bela H. Banathy's work on participatory decisionmaking and collaborative approaches to social-system design. In connection with the International Federation for Systems Research and the International Systems Institute, Banathy initiated a series of "conversations" in social-systems design, one held biennially in Fuschl, Austria, and another held annually in Asilomar, California. Unlike most conferences, these week-long conversations involve teams of scholars and other professionals from several different countries in a collaborative process of research and writing, beginning several months before the actual conversation and extending beyond as the teams complete their reports. Drawing on this experience, Patrick Jenlink and Charles Reigeluth have worked with school districts and local communities, applying Banathy's principles of social-systems design in developing a collaborative approach to educational-systems design. More recently, Banathy and Jenlink have initiated the Agora Project, an effort to rekindle the spirit of democracy and create a forum for public discourse, bringing people together within the local community to discuss issues of local concern.[97]

These are only a few examples, but they are illustrative of efforts within the systems community to foster participatory approaches to problem solving and decisionmaking. All of the above individuals acknowledge the inspiration they have drawn from Boulding's perspective on systems. In the concluding section of the book, I trace the evolution of the SGSR and illustrate developments within the general-systems community that have nurtured this orientation. Clearly this is not the only focus of the society, and there is important work in other dimensions of the systems tradition that has emerged from this group. But it is this tradition of collaborative systems design that holds the most fascination for me in connection with my original quest to understand the social implications of systems thought.

NOTES

1. Kenneth Boulding, selected verses from "A Ballade of Maturity," *CU-Boulder Summit* 9:1 (spring 1992): 28. Boulding read his ballade at a dinner for past presidents and staff of the AAAS, some of whom, he says, were annoyed by it, particularly those who had worked for the military. An early draft of this chapter was published as "Perspectives from the Boulding Files," in *Systems Research* 12:4 (1995): 281–290.

2. Kenneth Boulding, *The Skills of the Economist* (Cleveland: Howard Allen, 1958).

3. Kenneth Boulding, "A Bibliographic Autobiography," *Banca Nazionale del Lavorno Quarterly Review* 171 (Dec. 1989): 369; Larry Singell, "Memorial Address," April 16, 1993 (from memorial collection of obituaries and memorial statements compiled by Boulding's wife, Elise, entitled "Kenneth Ewart Boulding: 1910–1993," hereafter referred to as KEB Memorial, with page numbers referring to this document), p. 40. See also Kenneth Boulding, "My Life Philosophy," *The American Economist* 29:2 (fall 1985): 9; and Letter to Anatol Rapoport, Aug. 23, 1985 (Correspondence Files in Kenneth Boulding Collection in the University Archives at the University of Colorado at Boulder, hereafter referred to as KEB/CU), in which he writes that his contributions to economics have been rejected by the profession. Other awards include the American Council of Learned Societies Prize for Distinguished Scholarship in the Humanities (1962), the Frank E. Seidman Distinguished Award in Political Economy (1976), and the Rufus Jones Award of the World Academy of Arts and Sciences. See K. A. Fox and D. G. Miles, *Systems Economics: Concepts, Models, and Multidisciplinary Perspectives* (Ames: Iowa State University Press, 1987), p. xi.

4. First statement quoted in *Washington Post,* March 20, 1993 (KEB Memorial), p. 5. The second was a theme often repeated in many of his works. See for example Kenneth Boulding, "Introduction," in Larry Singell, ed., *Collected Papers*, *Vol. IV: Toward a General Social Science* (Boulder, CO: Associated University Press, 1971) and *A Reconstruction of Economics* (New York: Wiley, 1950), p. vii; also "A New Look at Institutionalism," *American Economic Review* 47:2 (May 1957): 12, for a discussion of commodities and people.

5. See the following articles in KEB Memorial: *Daily Camera,* March 19, 1993, p. 1; *Colorado Daily,* March 19, 1993, p. 2; *New York Times,* March 20, 1993, p. 4; Christie Boulding, Friends Memorial Service Program, March 28, 1993, p. 9; and *The COPRED Peace Chronicle* 18:2–3 (July 1993): 21. The IPRI, founded with his wife, Elise, who collaborated with him in most of his peace research work, had 800 individual and 100 institutional members. He also provided the inspiration for the International Society for Ecological Economics, which offers an annual Kenneth Boulding award.

6. Kenneth Boulding, *Conflict and Defense: A General Theory* (New York: Harper, 1962); *Economic Analysis* (New York: Harper, 1941); *The Impact of the Social Sciences* (New Brunswick, NJ: Rutgers University Press, 1966), pp. 36–37; "A Bibliographic Autobiography," p. 392; Cynthia Kerman, *Creative Tension: The Life and Thought of Kenneth*

Boulding (Ann Arbor: University of Michigan Press, 1974), pp. 20, 38; and the following articles from KEB Memorial: *Colorado Daily,* March 19, 1993, p. 2; *London Times,* March 22, 1993, p. 6; *The COPRED Peace Chronicle,* p. 22; and C. Boulding, Friends Memorial Service Program, March 28, 1993, p. 9.

7. Kenneth Boulding, Letter to John Scott Mabon (editor of Kerman's biography of Boulding, *Creative Tension*), Aug. 5, 1971 (KEB/CU, Correspondence); Kerman, *Creative Tension,* pp. 22, 31; Colman McCarthy, "Trailblazer of Peace," *Washington Post,* April 13, 1993, p. 5, and William Boulding, "Remarks for University of Colorado Memorial Service," p. 51 (both in KEB Memorial); and Kenneth Boulding, "The Next Thirty Years in General Systems," *General Systems* 29 (1985): 4.

8. Kenneth Boulding, *The Image: Knowledge in Life and Society* (Ann Arbor: University of Michigan Press, 1956), p. 146; Robert Wright, "Bould Over," *The New Republic,* May 17, 1993 (KEB Memorial), p. 18.

9. *Daily Camera,* March 19, 1993, p. 1, and *CoPred Peace Chronicle,* July 1993, p. 21 (both in KEB Memorial). Chancellor Corbridge suggested that William James's definition of genius as "the faculty of perceiving in an unhabitual way" applied to Boulding, in "Introductory Remarks: A Celebration of the Life of Kenneth Boulding," April 16, 1993 (KEB Memorial), p. 34.

10. *Colorado Daily,* March 19, 1993, p. 2, William Boulding, "Remarks," p. 51, and *London Independent,* April 13, 1993, p. 10 (all in KEB Memorial); Kenneth Boulding, Letter to Dr. Hans R. Friedli of Dow Chemical, Jan. 26, 1967 (KEB/CU, Correspondence).

11. *New York Times,* March 20, 1993 (KEB Memorial), p. 4; Kerman, *Creative Tension,* pp. 9, 107; Kenneth Boulding, "The Crisis of the Democratic Party," sent to Walter Adams of Michigan State University on Dec. 22, 1966 (KEB/CU, Unpublished Papers); Letter to J. A. Beirne (Jan. 25, 1966), then president of the Communications Workers of America (KEB/CU, Correspondence).

12. Letter to Humphrey (July 5, 1966) and Letter to Riesman (July 20, 1968), both in KEB/CU, Correspondence). The letter to Riesman was in response to a request (to which he agreed) to serve on a committee of social-science advisors for Senator Eugene McCarthy in his presidential campaign.

13. Long quote from Kenneth Boulding, "Systems Research and the Hierarchy of World Systems," *Systems Research* 2:1 (1985): 8–10; also "The Limits of Cybernetics," keynote address to the American Society for Cybernetics, Oct. 7, 1983 (KEB/CU); Kerman, *Creative Tension,* pp. 16, 20; and Wright, "Bould Over," p. 18, and Larry Senesh, introduction to concert performance of hymns and carols by Boulding, p. 25 (both in KEB Memorial).

14. Proceedings of the 7th Friends Association for Higher Education Conference, Malone College, 1986, p. 4, quoted in Paul Mangelsdorf, "Memorial Tribute," June 1993 (KEB Memorial), p. 62. See also Kerman, *Creative Tension,* pp. 106, 148, 265.

15. Boulding, "Systems Research," p. 11. White's article, included in Boulding's memorial collection (pp. 70–72), was originally written for the *Encyclopedia of the Environment,* which had not yet been published at the time. See also Ann Markusen, "Kenneth Boulding: A Reflection" (KEB Memorial), p. 45; Kenneth Boulding, "The Economics of the Coming Spaceship Earth," in Henry Jarrett, ed., *Environmental Quality in a Growing Economy: Essays from the Sixth Resources for the Future Forum* (Baltimore: Johns Hopkins Press, 1966), pp. 3–14 (reprinted in Kenneth Boulding, *Beyond Economics: Essays on Society, Religion, and Ethics* (Ann Arbor: University of Michigan Press, 1968), pp. 275–287; and William L. Thomas Jr., *Man's Role in Changing the Face of the Earth* (Chicago: University of Chicago Press, 1956).

16. Colman McCarthy, "Trailblazer of Peace," *Washington Post,* April 13, 1993 (KEB Memorial), p. 11; Kerman, *Creative Tension,* pp. 170, 225.

17. Kerman, *Creative Tension,* pp. 89–90, 171; Boulding, "A Bibliographic Autobiography," p. 367.

18. Boulding, "My Life Philosophy," pp. 5, 7; "Systems Profile: Some Origins," *Systems Research* 4:4 (1987): 285; Kerman, *Creative Tension,* pp. 91–98, 114, 117.

19. Kerman, *Creative Tension,* pp. 90, 234. During this period he applied for a fellowship to Christ Church. Copies of a recommendation were accidently sent to him, reading, "This is a bright boy but he is not one of us" (Boulding, "A Bibliographic Autobiography," p. 370). In 1943 Boulding applied for his doctorate by submitting a paper according to the standard procedure, but it was not granted.

20. Kerman, *Creative Tension,* pp. 99–106.

21. Kerman, *Creative Tension,* pp. 26–29, 235–241; Peter Boettke, "Kenneth Boulding: Old-Fashioned Economist" (KEB Memorial), pp. 16–17; Boulding, "My Life Philosophy," p. 6; and "Systems Profile," p. 285. Herman Daly discusses Fisher's influence on the development of Boulding's thought in *Steady-State Economics: The Economics of Biophysical Equilibrium and Moral Growth* (San Francisco: W. H. Freeman, 1977), p. 36. Boulding's father died during the summer of 1933, so he returned to Liverpool to help take care of his affairs, commenting that he learned more from the bookkeepers than he had in all of his previous economics courses ("My Life Philosophy," p. 6).

22. Kenneth Boulding, *A Reconstruction of Economics* (New York: Wiley, 1950); Kerman, *Creative Tension,* pp. 13, 34, 40, 67, 118, 144–146, 243–247.

23. Kerman, *Creative Tension,* pp. 121–123; Boulding, "My Life Philosophy," p. 8; and from KEB Memorial: *Washington Post,* March 20, 1993, p. 5; Mangelsdorf, "Memorial Tribute," p. 57; and *Daily Camera,* March 19, 1993, p. 1. While he originally registered as a conscientious objector, that would have required him to work in a Civilian Public Service Camp. During the psychiatric exam to determine his status, he tried to explain the Quaker doctrine of the Inner Light. The psychiatrist asked him if he ever heard the voice of God, and since Boulding did not deny this directly, he was given his deferment.

24. Boulding, "A Bibliographical Autobiography," pp. 375–376; "Systems Profile," pp. 285–286; Kerman, *Creative Tension,* pp. 7, 43.

25. Boulding, "A Bibliographic Autobiography," p. 385; *A Reconstruction of Economics* (preface to second edition, 1967); Kenneth Boulding, *The Structure of a Modern Economy* (New York: New York University Press, 1993); *Principles of Economic Policy* (Englewood Cliffs, NJ: Prentice-Hall, 1958); "The Economics of the Coming Spaceship Earth"; Larry Singell, CU Memorial Service (KEB Memorial), p. 40; Fox and Miles, *Systems Economics,* p. x; Kerman, *Creative Tension,* p. 31; Daly, *Steady-State Economics*. This view is most vividly described in Boulding's "bathtub theorem," in which the level of water (or of any capital stock) is determined by the *relationship* between input and output, not by the rate of flow through the system. He used a similar analogy in his description of molecules passing through a lake (Kerman, *Creative Tension,* p. 41). Appealing to the concept of the homeostasis of the balance sheet, Boulding saw income as derivative rather than primary.

26. Boulding, *A Reconstruction of Economics,* pp. 4–6, 26–37.

27. Boulding, *A Reconstruction of Economics,* pp. 4, 303.

28. *Rocky Mountain News,* March 19, 1993 (KEB Memorial), p. 3; Kerman, *Creative Tension,* pp. 75, 124.

29. Charles Middleton, CU Memorial Service, p. 36; *Colorado Daily,* March 19, 1993, p. 2; *Rocky Mountain News,* March 19, 1993, p. 3 (all from KEB Memorial). The subject matter of the course on general social dynamics is presented in Boulding's "manifesto,"

Ecodynamics: A New Theory of Societal Evolution (Beverly Hills, CA: Sage Publications, 1978). Along with *The World as a Total System* (Beverly Hills, CA: Sage Publications, 1985), this book provides a good overall synthesis of Boulding's systems approach.

30. Kenneth Boulding, "The Desert Frontier: Economics and the Behavioral Sciences," summary of address given at the University of California at Berkeley on Dec. 16, 1954 (in Box 5 of the Kenneth E. Boulding Collection at the Bentley Historical Library at the University of Michigan in Ann Arbor, hereafter referred to as KEB/MI), pp. 2–4. This paper was later published in *Diogenes* 15 (fall 1956): 1–14. Boulding saw social psychology as the core of the behavioral sciences; sociology, anthropology, and psychology as "respectable members"; economics and political science as "disreputable members"; and history as somewhat of an outsider (p. 4 of manuscript version).

31. "Report of the Study for the Ford Foundation on Policy and Program," in the introduction to "Program Area Five: Individual Behavior and Human Relations," reproduced in Arnold Thackray, "CASBS: Notes Toward a History," *CASBS Annual Report* (1984), p. 63; Kenneth Boulding, *The Organizational Revolution: A Study in the Ethics of Economic Organization* (New York: Harper, 1953).

32. Boulding, *Organizational Revolution,* pp. xi, xxvii, 21–25. Boulding's understanding of growth is derived from D'Arcy Thompson, *On Growth and Form* (Cambridge: Cambridge University Press, 1917), which he cites as one of the major influences on his thinking. These ideas were also central to Boulding's analysis of conflict. See his introduction to "Organization and Conflict," *Journal of Conflict Resolution* 1:2 (June 1957): 122–123.

33. Kenneth Boulding, "The Taming of Mammon," in Lynn White Jr., ed., *Frontiers of Knowledge* (New York: Harper and Brothers, 1956), reprinted in Kenneth Boulding, *Beyond Economics: Essays on Society, Religion, and Ethics* (Ann Arbor: University of Michigan Press, 1968), pp. 28–42.

34. Boulding, *Organizational Revolution,* pp. 34, 52.

35. Ibid., pp. xxviii, xxxii, 68–70 (quote p. 69).

36. Ibid., pp. 53–54.

37. Letter from Ayers, April 6, 1955, and Boulding's response of April 11, 1955 (KEB/MI, Box 5); Boulding, "A New Look at Institutionalism," pp. 1–2, 10, 12. Boulding includes a discussion of Marx in the context of his broader analysis of traditions of dissent. His earlier rejection of institutionalist ideas had derived from his reading of Rexford Tugwell, ed., *The Trend of Economics* (New York: A. A. Knopf, 1924), which he later realized was too limited in its interpretation.

38. Kerman, *Creative Tension,* pp. 13, 26, 41; Boulding, "Systems Profile," pp. 285–286; "Summary of University Report" (KEB/MI, Box 29), pp. 1, 3–4.

39. Letter to Center Fellows from Ralph Tyler, June 14, 1955 (KEB/MI, Box 26); Memo on "The Social Science Research Project of the University of Michigan," Amos Hawley, Nov. 15, 1947 (KEB/MI, Box 39); "Summary of University Report," p. 1; Letter from Bernard Berelson, director of Behavioral Sciences Division, Oct. 7, 1952 (KEB/MI, Box 42); "Digest of Replies to Letter Concerning Report of Advisory Group," July 1952 (KEB/MI, Box 23).

40. "Digest of Replies," pp. 9–10; "Notes from Morning Session," Advisory Group Meeting, Oct. 17, 1953 (KEB/MI, Box 23), p. 6.

41. "Digest of Replies," p. 25.

42. Boulding, Letter to Reverend E. F. Molnar, Feb. 11, 1955 (KEB/MI, Box 5); "Editorial," Jan. 13, 1959 (KEB/MI, Box 7); "Communism Rival Faith for Christ," *Michigan Daily,* March 10, 1959 (KEB/MI, Box 10); "Bibliographic Autobiography," p. 384.

43. Kenneth Boulding, *A Primer on Social Dynamics: History as Dialectics and Development* (New York: The Free Press, 1970), p. 95; *The Impact of the Social Sciences,* pp. 33–34; and *Colorado Daily,* March 19, 1993 (KEB Memorial), p. 2. Regarding Marxism and Christianity, see Kenneth Boulding, Review of Lester de Koster, *All Ye That Labor: An Essay on Christianity, Communism, and the Problem of Evil* (KEB/MI, Box 6), and "Communism Rival Faith for Christ."

44. Kenneth Boulding, "The Role of the Intellectual in the Modern World," summary of lecture, Sept. 10, 1964 (KEB/CU, Unpublished Papers); *The Impact of the Social Sciences,* p. 33; "A New Look at Institutionalism," p. 10; *A Primer on Social Dynamics,* pp. 76–82; Kenneth Boulding, "The Relations of Economic, Political, and Social Systems," *Social and Economic Studies* 11:4 (Dec. 1962): 353; and "Organizing Growth," *Challenge* 8:3 (Dec. 1959): 108–112.

45. Kenneth Boulding, *Evolutionary Economics* (Beverly Hills, CA: Sage Publications, 1981), p. 40.

46. Kenneth Boulding, "To the Communists" (KEB/MI, Box 6); Letter to Editor, *Senate Affairs,* March 10, 1954 (KEB/MI, Box 5); Letter to Dean Odegaard, April 11, 1955 (KEB/MI, Box 5). In his characteristic style, he goes on to state his views as follows: "I am myself an anti-communist, a devotee of the free market, a detester of totalitarianism, a believer in liberty, and such experience as I have had with communists has been nauseating. Nevertheless, I believe it important that people be nauseated, and if the university community, and especially the students, are over-protected from communist influence there is grave danger that they may lose that immunity which actual contact with communists is liable to produce" (Letter to Editor, above).

47. See "Summary of 4th Meeting of Faculty Research Committee on Arms Control," Sept. 14, 1961, p. 1 (KEB/MI, Box 42); Kenneth Boulding, Letter to Thomas Carroll, Ford Foundation, March 18, 1958 (KEB/MI, Box 7); and "Dinosaurs and Personal Freedom," May 19, 1958 (KEB/MI, Box 7). See also Boulding, "The World War Industry as an Economic Problem," September 14, 1961 (KEB/MI, Box 42); and "Statement on behalf of AFSC before Senate Subcommittee on Disarmament," June 8, 1959 (KEB/MI, Box 6).

48. Leonard Lewin, ed., *Report from Iron Mountain* (New York: Dial Press, 1967). See Horowitz's introduction to comments in response to the report, in "Report from Iron Mountain," in Kenneth Boulding, ed., *Peace and the War Industry* (Chicago: Aldine, 1970), pp. 53–81 (quotes pp. 54, 58, 68). Boulding and Anatol Rapoport are among the eight whose comments were included.

49. Kenneth Boulding, Letter to Edward Teller, April 5, 1958 (KEB/MI, Box 7); "Open Letter Regarding Establishment of US Arms Control and Disarmament Agency" (KEB/MI, Box 7); and Letter to Eisenhower (KEB/MI, Box 7).

50. Kenneth Boulding, Prospectus for 1950–1951 Seminar in Problems in the Integration of Social Science, (KEB/MI, Box 40).

51. Kenneth Boulding, "The Theory of Competitive-Cooperative Relationships: Summary and Conclusions" (KEB/MI, Box 40); Memo regarding Seminar on Competition and Cooperation (KEB/MI, Box 40); "Systems Profile," p. 286.

52. Kenneth Boulding, "Contribution of Economics to the Other Sciences," lecture given to sociology colloquia, May 13, 1953 (KEB/MI, Box 5); "Seminar on Problems of Integration in the Social Sciences: An Introductory Note," pp. 1–2 (KEB/MI, Box 41); and "Competition in Economics" (KEB/MI, Box 40). Boulding often described knowledge as a layer cake, with disciplines as the layers and applied arts as the slices, and "no real hierarchy among the layers." He often used a similar metaphor, with knowledge as a hotel with many stories, but essentially the same floor plan.

53. Boulding, "Contribution of Economics"; *Evolutionary Economics,* p. 17; *The Impact of the Social Sciences,* p. 18. Boulding tended to be critical of historians, although he acknowledges, in his discussion of the image, that they play a critical role, for better or worse, in shaping public images, in support of nationalism for example. He suggested that it was important to understand the "social processes by which history gets written" (*A Primer on Social Dynamics,* p. 112).

54. Kenneth Boulding, "Notes on a General Theory of an Individual" and "Notes on the Contribution of the Biological Sciences Toward an Integrated Theory of the Individual" (KEB/MI, Box 40).

55. Kenneth Boulding, "A Conceptual Framework for the Social Sciences," in *Beyond Economics,* p. 59; "General Systems Theory: The Skeleton of Science," *Management Science* 2:3 (April 1956): 197–208; "The Relations of Economic, Political, and Social Systems," in Larry Singell, ed., *Collected Papers, Vol. IV: Toward a General Social Science* (Boulder, CO: Colorado Associated University Press, 1971), p. 153. See also Boulding, *The World as a Total System,* pp. 18–28; *The Image,* pp. 20–31; and "Prospectus for a Joint Seminar in Theoretical Systems and Practical Decisions" (KEB/MI, Box 29). An additional level that he sometimes included in the list is the transcendental level, which included religion and art, that might be subsumed in the level of symbolic systems. In the table I have generally used Boulding's terms for the description and characterization of each level, except at the highest two levels where I have added to his rather brief descriptions based on the later development of his ideas.

56. Boulding, "Systems Profile," p. 286.

57. Kenneth Boulding, "Interdisciplinary Seminar in the Theory of Growth" (KEB/MI, Box 40); and "A Conceptual Framework," pp. 57–63.

58. Kenneth Boulding, Letter to Bertalanffy, Nov. 25, 1953; Letters to Boulding from Bertalanffy, Dec. 16, 1953, and Jan. 25, 1954 (all from KEB/MI, Box 29); Letter from Rapoport, June 7, 1954 (KEB/MI, Box 5). Bertalanffy had first proposed the idea of GST in an earlier article. Boulding had been thinking in terms of what he had called "General Empirical Theory," but he adopted Bertalanffy's term after reading his 1953 article.

59. Boulding, *The Image;* "My Life Philosophy," p. 10; "Prospectus: Interdisciplinary Seminar in the Integration of the Social Sciences" (KEB/MI, Box 40); "A Bibliographical Autobiography," p. 378; Kerman, *Creative Tension,* p. 50. See George Miller, Eugene Galanter, and Karl Pribram, *Plans and the Structure of Behavior* (New York: Holt, Rinehart, and Winston, 1960). Boulding dictated *The Image* in two weeks as he was packing to return to Ann Arbor at the end of the year at CASBS.

60. Kenneth Boulding, "Notes on the Information Concept in General Systems Theory," pp. 7, 10 (KEB/MI, Box 27). This is a longer preliminary draft of the 1955 paper, originally published in *Exploration* 6 (1955), and reprinted in Larry Singell, ed., *Collected Papers, Vol. IV: Toward a General Social Science* (Boulder, CO: Associated University Press, 1971).

61. Boulding, *The Image,* p. 6; "Prospectus: Interdisciplinary Seminar in the Integration of the Social Sciences" (KEB/MI, Box 40); "Notes on the Information Concept"; "Bibliographic Autobiography," p. 387.

62. Boulding, "Secular Images of Man in the Social Sciences," in Larry Singell, ed., *Collected Papers, Vol. IV: Toward a General Social Science* (Boulder, CO: Associated University Press, 1971), p. 83; "Introduction," in Larry Singell, ed., *Collected Papers, Vol. IV: Toward a General Social Science* (Boulder, CO: Associated University Press, 1971), p. viii; "Outline of the Image," (KEB/MI, Box 27).

63. From Kenneth Boulding, *Beasts, Ballads, and Bouldingisms* (New Brunswick, NJ: Transaction Books, 1980), p. 65; also reproduced in KEB Memorial, p. 93.

64. Boulding, *The World as a Total System,* p. 17; *The Image,* pp. 31, 34, 37.

65. Boulding, *The Impact of the Social Sciences,* p. 4; *Ecodynamics,* p. 19; *A Reconstruction of Economics,* pp. 6–7; *A Primer on Social Dynamics,* pp. 20–21; and *The World as a Total System,* p. 82. See also Kenneth Boulding (with Michael Kammen and Seymour Martin Lipset), *From Abundance to Scarcity: Implications for the American Tradition* (Columbus: Ohio University Press, 1978), pp. 17–18; and Richard Dawkins, *The Selfish Gene* (New York: Oxford University Press, 1976).

66. Kenneth Boulding, "General Systems as a Point of View," in Mihajlo Mesarovic, ed., *Views on General Systems Theory* (New York: Wiley, 1964), pp. 216–217; *Evolutionary Economics,* pp. 17–18; *Ecodynamics,* pp. 21–24; *A Primer on Social Dynamics,* p. 18; and *From Abundance to Scarcity,* p. 35.

67. Boulding, *The Image,* p. 149; *Impact of the Social Sciences,* pp. 41–43.

68. Boulding, *Impact of the Social Sciences,* pp. 64, 105.

69. Kenneth Boulding, from "The Feather River Anthology," in *Beasts, Ballads, and Bouldingisms,* p. 111. Other quotes from "Notes on the Information Concept," p. 25; and *The Image,* p. 14.

70. Kenneth Boulding, "Political Implications of General Systems Research," *General Systems* 6 (1961): 1; "To the Seminar in the Theory of Information and Communication" (KEB/MI, Box 40); "Outline of the Image" (KEB/MI, Box 27), p. 6; Kerman, *Creative Tension,* p. 44.

71. Boulding, *The Image,* p. 171; "Outline of the Image," pp. 2, 7.

72. Boulding, "Outline of the Image," pp. 9–10; *The Image,* pp. 151–152, 162–163, 175. Boulding describes the sociology of knowledge as "a refugee from Germany that settled down at the University of Chicago," and suggests that George Mead might be seen as the first eiconist (*The Image,* pp. 149–150).

73. Kenneth Boulding, *The Meaning of the Twentieth Century* (New York: Harper & Row, 1964), p. 43. Boulding's thoughts in this area were greatly influenced by Fred Polak, whom he had met at CASBS, and his book, *The Image of the Future* (New York: Elsevier, 1973), which was translated into English from the original Dutch by Elise Boulding.

74. Kenneth Boulding, "Prospectus, Spring 1958," and notes from 13th and 15th meetings, May 13, 1958, and May 27, 1958 (KEB/MI, Box 41).

75. Kenneth Boulding, Letter to Lyman Bryson, Jan. 7, 1958, regarding a proposed article for a symposium that Bryson was organizing (KEB/MI, Box 7). Longer quote from Boulding, "Systems Profile," pp. 287–288.

76. Kenneth Boulding, "Prospectus for a Joint Seminar in Theoretical Systems and Practical Decisions"; and "Introduction: Seminar in Theoretical Systems and Practical Decisions" (both in KEB/MI, Box 29); "My Life Philosophy," p. 10.

77. Kenneth Boulding, Abstract of first seminar meeting, Feb. 14, 1956; and "Propositional Summary of a General Theory of Conflict," p. 5 (both in KEB/MI, Box 40). In his notes on Robert Angell's discussion of the distinction between organism and system, entitled "Excerpts from the Moral Web in Social Change," Boulding writes: "Although most schools of sociology have long since forsaken Spencer's analogy to the biological organism, they do not reject the notion that society is, like each of its included groups, a system. . . . Society adjusts to its problems as a whole, the parts are interrelated, and they perform specialized tasks for the whole. . . . Where we part company with Spencer is in his supposing that the necessary functions are closely analogous to those required in a biological organism or are allocated in any fixed way to particular parts" (KEB/MI, Box 41).

78. Boulding, *The World as a Total System,* p. 171; "Notes on the Information Concept," p. 27. See also Kenneth Boulding, *Conflict and Defense: A General Theory* (New York: Harper, 1962), pp. 123–144; and Kerman, *Creative Tension,* p. 48. Two of Richardson's

books were published in 1960: *Arms and Insecurity: A Mathematical Study of the Causes and Origins of War* (Pittsburgh: Boxwood Press, 1960) and *Statistics of Deadly Quarrels* (Pittsburgh: Boxwood Press, 1960). Rapoport wrote a summary of his work, "Lewis Richardson's Mathematical Theory of War," that was published in *The Journal of Conflict Resolution* 1 (1957).

79. Kenneth Boulding, Abstract of first seminar meeting, Feb. 14, 1956 (KEB/MI, Box 40); *Stable Peace* (Austin: University of Texas Press, 1978), pp. 138–139; "Theory of Games in Economic Behavior" (KEB/MI, Box 40); and "Political Implications," p. 3.

80. Kenneth Boulding, Summaries of sessions (KEB/MI, Box 40); "Organization and Conflict," p. 132. Final quote from "Can Violence Bring Peace?" (KEB/MI, Box 6), p. 1.

81. Boulding, *Conflict and Defense,* appendix to ch. 14.

82. Boulding, "Propositional Summary of a General Theory of Conflict," pp. 5–6; Notes from talk on "Role of Communication in Peace Research," Dec. 8, 1961 (KEB/MI, Box 8); "Notes on the Information Concept," p. 26; "Notes on the problems of political theory"; and prefatory note regarding application for funding for journal (both in KEB/MI, Box 40); "A Proposal for a New Journal" (KEB/MI, Box 41). See also handout for Seminar VI: Ralph Gerard, Cooperation and Conflict (KEB/MI, Box 40).

83. Boulding, *The Impact of the Social Sciences*, pp. 64–70; *Stable Peace,* p. 118.

84. Boulding, "Organization and Conflict," pp. 127–128.

85. Long quote from Religious News Service, report on Boulding's lecture, "The Principles of Personal Responsibility in Economic Life," Jan. 5, 1954 (KEB, Box 5). See also Boulding, *The Image,* pp. 114, 129; *The Meaning of the Twentieth Century,* p. 146; and "A Bibliographic Autobiography," p. 380. Discussions of these three forces can be found in many of Boulding's writings. The most thorough overview is in Kenneth Boulding, *Three Faces of Power* (Newbury Park, CA: Sage Publications, 1989). Further exploration of the integrative concept led to his work on the grants economy, addressed in *The Economy of Love and Fear: A Preface to Grants Economics* (Belmont, CA: Wadsworth, 1973).

86. Kenneth Boulding, "Introduction," "The Relations of Economic, Political, and Social Systems," and "Technology and the Integrative System," in Larry Singell, ed., *Collected Papers*, *Vol. IV: Toward a General Social Science* (Boulder, CO: Associated University Press, 1971), pp. viii, 157–162, 397.

87. Boulding, *The Organizational Revolution,* pp. xxxi–xxxii.

88. Boulding, *A Primer on Social Dynamics,* pp. v–vii, 105. The book was not actually published until 1970, but his introduction acknowledges his debt to the Japanese students who stimulated his thinking on this issue.

89. Boulding, *The Meaning of the Twentieth Century,* pp. 179, 190–194; *A Primer on Social Dynamics,* pp. 63–66, 94–95, 109. Boulding pointed out that President Johnson's portrayal of poverty "as an enemy to be fought rather than a problem to be solved" reinforced this kind of thinking.

90. Kenneth Boulding, "The Boulding's Eye View of General Systems" (KEB/CU, Unpublished Papers), pp. 2, 12.

91. Long quote from Boulding, "The Next Thirty Years," p. 3; also "The Hierarchy of World Systems," p. 11; and "Political Implications," pp. 5–6.

92. Boulding, Letter to Dean Harlan Cleveland, June 11, 1958; and Press Release, University of Michigan News Service, March 11, 1958 (both in KEB/MI, Box 7). Also Boulding, *The Meaning of the Twentieth Century,* pp. 198–199; and Kerman, *Creative Tension,* pp. 42, 344.

93. Kenneth Boulding, Outline for "Political Implications" (KEB/MI, Box 6), p. 3; "The Boulding's Eye View," p. 16.

94. Boulding, *Beasts Ballads, and Bouldingisms,* pp. 131–132; Letter to Joseph Willits, Dec. 11, 1961, regarding his article “A Study of Excellence and Mediocrity” (KEB/MI, Box 8); and “Digest of Replies” (KEB/MI, Box 23), p. 2.

95. Richard Norgaard, “A Case for Methodological Pluralism,” *Ecological Economics: The Journal of the International Society for Ecological Economics* 1:1 (Feb. 1989); Richard Norgaard and Sharad Lélé, “Sustainability and the Scientist’s Burden,” *Conservation Biology* (June 1996). Norgaard holds a joint professorship in the Energy and Resources Group and the Department of Agriculture and Resource Economics at UC Berkeley. Although he has not been directly involved in the systems community, he served as president of the International Society for Ecological Economics (which offers an annual Kenneth Boulding award) from 1998 to 2001, and his work reflects Boulding’s conception of the significance of general-systems thinking.

96. Reckmeyer is professor of leadership and systems at San Jose State University and senior fellow in the James Burns Academy of Leadership at the University of Maryland. I was introduced to his work at a workshop on “A Systems Approach to Leadership,” sponsored by the Kellogg Foundation, which he invited me to attend (December 1994 in San Jose, CA). Quote from Reckmeyer’s web site: www.academy.umd.edu/aboutus/staff/BReckmeyer.htm.

97. See Bela Banathy, *Systems Design of Education: A Journey to Create the Future* (Englewood Cliffs, NJ: Educational Technology Publishers, 1991); *A Systems View of Education: Concepts and Principles for Effective Practice* (Englewood Cliffs, NJ: Educational Technology Publishers, 1992); *Designing Social Systems in a Changing World* (New York: Plenum Press, 1996); Patrick Jenlink, “Designing Educational Systems for the Twenty-First Century,” *Systems Research and Behavioral Science* 18 (2001): 283–285. Banathy and Jenlink presented their work on the Agora Project at the 2001 annual conference of the International Society for the Systems Sciences, and one of the teams at the Fuschl Conversation in 2002 focused on strategies for implementing the project in different settings.

PART III
Evolution and Evaluation

NINE

The Society for General Systems Research: Establishment and Development

> Approaches to management of problems that affect people can be broadly described under two categories. One is adherence to top-down, expert-designed projects, and the other is the involvement of people in the analysis of problems that affect them and in the design of potential solutions. In the latter participatory approach all those involved contribute both to the creative thinking that goes into problem solving and planning.
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> —Nilamadhab Kar and Brajaballav Kar, "Social Cognition and the Participatory Planning Process"[1]

ORIGINS: THE CENTER FOR ADVANCED STUDY IN THE BEHAVIORAL SCIENCES

In statements describing their research interests for the year at the Center for Advanced Study in the Behavioral Sciences (CASBS), Ludwig von Bertalanffy, Kenneth Boulding, Ralph Gerard, and Anatol Rapoport each discussed their concern with the development of integrating theories for the biological, psychological, and social dimensions of human behavior. Boulding wrote: "My main interest at the moment is working toward the development of a body of 'general empirical theory' or 'general system theory' which will consist of an orderly arrangement of theoretical models which are useful in the interpretation of more than one of the 'empirical universes.'" In his correspondence with Ralph Tyler, he emphasized the importance of biology for an understanding of social processes. Boulding goes on to write, in his "Suggested Program for Work at the Center," that "it is clear that something like a general model of organization and behavior theory is emerging from many different fields, based on the notion of a servo-mechanism control system, information flows and knowledge structures, and the selective mutation of systems." In addition to such biological and technological models and concepts, all except Gerard highlighted their concerns with values and the symbolic dimensions of human behavior.[2]

Gerard discussed his interest in seeking "a mutually acceptable formulation of psychiatric concepts" for biologists, psychologists, and social scientists, in relation to his concept of the "epiorganism" as a social analogy of the biological organism. Rapoport focused on his work with neural networks and mathematical analogies between different content areas. In describing his goals for the year at CASBS, Bertalanffy submitted his proposal for an institute of general system theory, which Aldous Huxley had encouraged him to send to the Ford Foundation prior to the establishment of CASBS. Although the story is generally told that the idea for the society was hatched around the lunch table early that fall as they discovered their common interests, Bertalanffy and Boulding had already been corresponding about the possibility of creating such a forum and had sent out letters to a number of natural and social scientists who they thought might be interested in such a venture. They received several enthusiastic responses, including one from Rapoport. And of course Miller's Committee on the Behavioral Sciences had already been working toward the development of a general theory of living systems.[3]

In her biography of Boulding, Cynthia Kerman writes that he was "clearly one of the stars" among the CASBS fellows, entertaining everyone with his satirical wit and whimsical verse. Commenting on their efforts to mesh insights from the various disciplines, he suggested that perhaps they were becoming overly "messianic." Rapoport, reflecting on his own experience during that year, writes that it was "a model of a genuine 'community of scholars,' which Robert Hutchins had always insisted a university should be." He mentions, in particular, his connection with Alex Bavelas and Stephen Richardson. Bavelas was a student of Kurt Lewin and had translated Lewin's ideas about group dynamics into a mathematical model, using a mathematics of structure rather than quantity. Inspiring the eventual establishment of the Center for Peace Research at Ann Arbor, Richardson contributed the then unpublished work of his father, Lewis Richardson, who had died the previous year. Rapoport compared Richardson's mathematical analysis of arms races to Antoine Auguste Cournot's mathematical theory of duopoly and to his own mathematical models of social interaction. Gerard was one of senior members of the group, along with Franz Alexander, who had worked with Freud, and the two of them worked together toward a synthesis of concepts from neurophysiology and psychoanalysis. Clyde Kluckhohn, a Harvard anthropologist and also an elder among the group, brought a cross-cultural perspective on value structures from his work with the Navajo.[4]

The range of workshops and seminars available to the fellows was quite broad. Among nineteen workshops offered at the beginning of the year, Gerard and Rapoport presented one on social network theory, in partnership with Paul Lazarsfeld and Duncan Luce. With Raoul Naroll, Bertalanffy facilitated a workshop on allometric growth in social phenomena. Bertalanffy and Boulding were listed as the leaders for the workshop on general systems theory, which met weekly throughout the year. The first four introductory lectures were given by Bertalanffy, Boulding, Gerard, and Rapoport. Bertalanffy's introduction, basically an overview of his conception of general systems theory, was published in *Main Currents in Modern Thought* in March 1955. Boulding discussed economic systems in relation to the broader social context. Gerard's presentation, also published in *Main Currents in Modern Thought,* in August 1956, addressed levels of organization, while Rapoport focused on information systems. Additional topics included: foundations of physics; allometry in biological and social sciences; homeostasis in biology, psychology, and economics; the Malthusian problem; biological and cultural evolution; the Whorfian hypothesis; and theories of administration and international relations. In addition to members of the center, guests included Charles McClelland, from San Francisco State College; Herbert Simon, from the Carnegie Institute of Technology; and Lancelot Whyte, from London. The final report on the workshop noted that several publications had resulted from their collaborative efforts.[5]

According to the report on the GST workshop, the Society for the Advancement of General Systems Theory was launched "following a suggestion originally made by Boulding." A committee was established to explore the formation of the society, with Bertalanffy as executive secretary. The first organizational meeting was held at the 1954 annual convention of the American Association for the Advancement of Science (AAAS), which took place in Berkeley that December, in connection with the Philosophy of Science Section of the association. The purpose of the meeting was to "sound out the opinion of those interested as to the most useful form of organization." In the proposed statement of purpose for the society, which was included as part of the announcement of the meeting in the AAAS program, the primary goal of the society was to "encourage the development of theoretical systems which are applicable to more than one of the traditional departments of knowledge," with principle aims as follows:

1. To investigate the isomorphy of concepts, laws, and models in various fields, and to help in useful transfers from one field to another
2. To encourage the development of adequate theoretical models in areas which lack them
3. To eliminate the duplication of theoretical efforts in different fields
4. To promote the unity of science through improving the communication among specialists[6]

Bertalanffy and Boulding presented the program and scope of the proposed society. The turnout was more substantial than they had expected. According to varying estimates, between fifty and eighty people attended the meetings, several signing up as members of the society. The group decided that it was not yet time for the formal inauguration of the society, and that they would continue as a committee under the Philosophy of Science Section of the AAAS. Plans for a yearbook of articles relevant to GST from various disciplines were discussed and arrangements were made for another organizational meeting in connection with the next annual meeting of the AAAS, to be held in Atlanta. Bertalanffy began to work on the legal details of chartering the organization, which was financially supported by an initial grant from the Bostrum Foundation. A follow-up meeting was held at CASBS on February 26, 1955, with presentations from the work group on biological and cultural evolution, including Gerard, Kluckhohn, and Bavelas. In addition, a symposium on general systems theory was presented that September at the annual meeting of the

American Psychological Association in San Francisco, with papers by Bertalanffy on equifinality, Franz Alexander on the principle of homeostasis in physiology and psychology, and Raoul Naroll on the principle of allometry in biological and social science.[7]

Until the early 1980s the Society for General Systems Research (SGSR) continued to meet in conjunction with the annual meeting of the AAAS. In his report on the 1969 annual meeting, Milton Rubin, then president of SGSR, noted that "the broad interdisciplinary interests for which the Society stands has pervaded many other sessions of the AAAS meetings." While former sessions of the AAAS meetings had focused primarily on "pure scientific research results," most of the sessions in 1969 dealt with the "broader issues of relating science to society." The report of the first organizational meeting, held on December 27, 1954, summarizes the significance of GST for this broader concern:

> While, up to recent times, exact theory and the corpus of laws of nature was almost identical with theoretical physics, the modern development of the biological, behavioral, and social sciences necessitates an expansion of our conceptual schemes. There exist theoretical models, principles, and laws that apply to "systems" in general, irrespective of the particular properties of the system under consideration. Hence they are applicable in different fields, and give rise to often surprising structural similarities between quite different fields of human knowledge. Further, a main problem of modern science is a general theory of organization. Concepts like those of wholeness, directiveness, teleology, and the like, although alien to classical physics, cannot be avoided when dealing with biological, behavioral, and social phenomena.[8]

Looking back thirty years later, Boulding writes that the general-systems movement developed out of "a feeling among a slightly eccentric group of scholars that the disciplinary organization of the scientific and scholarly community had neglected or indeed violated the principle of basic structural unity in the systems of the universe." A flyer on the new society reflects this concern: "Problems of organization, wholeness, and dynamic interaction are urgent in modern physics, chemistry and technology," and similarly in biology and the social sciences. It continues: "Such parallel developments are even more dramatic if we consider the fact that they are mutually independent and largely unaware of each other." The aim of the society was thus "to expedite the development of cross-disciplinary concepts and theories, so as to prevent duplication of effort and [provide] mutual reinforcement." Boulding wrote: "Nobody, I think, had much ambition to construct a general theory of everything, though the feeling that the whole universe must be in some sense a single system was not wholly absent."[9]

ORGANIZATIONAL DEVELOPMENT

The Society for the Advancement of General Systems Theory was officially established at the AAAS meeting in Atlanta in 1956. Margaret Mead was in attendance and remarked that the society should apply systems principles to itself as an organization, with the aim of fostering a more collaborative and inclusive organizational structure. At the time, she reflected that her comments were received as if she were "a little old lady in tennis shoes," and yet this kind of self-reflexivity became increasingly central in both the theoretical orientation and the practical organization of the society. Her comments have actually become part of the lore of the society, as a hallmark of the innovative approach that characterized the group.[10]

The first election was held in May 1957, when Boulding was chosen as president, Bertalanffy as vice president, and Richard Meier, who was working with Miller's group at MHRI, as secretary-treasurer. The name was changed to the Society for General Systems Research, since the original name inaccurately implied the existence of a theory to be promoted. Although he was president, Boulding notes that Rapoport and Bertalanffy did most of the work, specifically in editing the yearbook, *General Systems,* which became the major forum for the evolution of general-systems thought, in addition to the annual conferences. Since Bertalanffy was not at Ann Arbor, most of the editorial work was done by Rapoport. Bertalanffy had done much of the initial work of chartering the society, although this became increasingly difficult with distance, and Meier, who had been involved with the theory group at both Chicago and Ann Arbor, took over the task. Gerard does not appear to have been very actively involved in the evolution of the society, although he did continue in the theory group, in connection with his research on behavioral science at the MHRI.[11]

Of those who attended the original meeting in 1954, 33 became members. By 1957 there were 147 members; in 1958 there were 494; and by the mid-1960s the membership stabilized around 1,000, although it has declined in recent years. Members included representatives from a broad academic spectrum: mathematics, electrical engineering, administrative theory, biophysics, ecology, psychiatry, psychology, economics, sociology, history, and philosophy of science. As noted in the society bulletin, "perhaps the major distinguishing characteristic of the Society is its capability to bring together for meaningful discourse such a diverse assemblage of scholars, researchers, and practitioners." Topics addressed in the yearbook during the first fifteen years included philosophy, methodology, mathematical systems theory, cybernetics and communication theory, computational and informational aspects of GST, automata and self-organization, game theory, natural science, biological science, population dynamics, environmental sciences, social science, economics, humanities and arts, education, cognition, psychology, psychotherapy, linguistics, cultural/moral/spiritual systems, health systems, management and decisionmaking, organization theory, engineering and technology, and legal and military applications.[12]

Although the original motivation for the society grew out of theoretical concerns in the behavioral sciences, Boulding noted in later years that the greatest interest in general systems was shown by business schools, and he acknowledged that the insights of GST were relevant to the development of practical management skills. In an article on "The Political Implications of General Systems Research," he

Table 9.1. Past Presidents of SGSR/ISSS[13]

1957–1958	Kenneth Boulding	1975–1976	Kjell Samuelson	1989–1990	C. West Churchman
1959–1961	Charles McClelland	1976–1977	Heinz von Foerster	1990–1991	Len Troncale
1962–1964	Ross Ashby	1977–1978	Geoffrey Vickers	1991–1992	Howard T. Odum
1965–1966	Anatol Rapoport	1978–1979	Richard Ericson	1992–1993	Ian Mitroff
1966–1967	Peter Caws	1979–1980	Brian Gaines	1993–1994	Hal Linstone
1967–1968	John Milsum	1980–1981	Robert Rosen	1994–1995	J.D.R. de Raadt
1968–1969	Milton Rubin	1981–1982	George Klir	1995–1996	Ervin Laszlo
1969–1970	Lawrence Slobodkin	1983–1984	Karl Deutsch	1996–1997	Yong Pil Rhee
1970–1971	Bertram Gross	1984–1985	Bela H. Banathy	1997–1998	G. A. Swanson
1971–1972	Stafford Beer	1985–1986	John Dillon	1998–1999	Bela A. Banathy
1972–1973	Margaret Mead	1986–1987	Peter Checkland	1999–2000	Peter Corning
1973–1974	James Miller	1987–1988	Russell Ackoff	2000–2001	Harold Nelson
1974–1975	Gordon Pask	1988–1989	Ilya Prigogine	2001–2002	M. C. Jackson

Note: Name changed to International Society for the Systems Sciences (ISSS) in 1988.

wrote that the systems movement, "of which SGSR is merely one aspect," was reflected in such publications as *Management Science, Administrative Quarterly, Journal of Operations Research,* and the *Journal of Conflict Resolution;* as well as in such institutions as MHRI, the RAND Corporation, and the computer industry. As a result, Boulding suggested that GST had important political consequences, particularly in terms of the relationship between knowledge and power.[14]

Originally the position of president was a three-year appointment. In his letter to Charles McClelland in 1958, asking him if he would accept nomination as the next president, Boulding wrote that the society had been a "very casual and informal affair," and that he had a fairly modest view of the responsibilities and opportunities of the office, although "we stand somewhat at a parting of the ways." As the society evolved, the primary responsibility of the president was the planning of the annual conference. In general, the position was reserved for those who had made a substantial contribution to the evolution of systems thought; Table 9.1 lists those holding the office over the course of the society's history.[15]

By 1959 regional groups had begun to meet in New York and California. Twelve years later, there were five regional divisions in the United States: Northeast, Midwest, Southeast, Southwest, and Far West; local chapters in Boston, New York, and London; and growing interest in Europe, where the term "cybernetics" was used interchangeably with GST. In 1970 the International Federation of Systems Research was jointly proposed by the Netherlands Society for Systems Research and the Austrian Society for Cybernetics Studies. By 1974 SGSR itself had several overseas divisions including the United Kingdom, North Europe, West Asia, and Japan. And in 1984 it claimed members from thirty-eight countries. The twenty-fifth anniversary meeting in 1979 was held in London to acknowledge the growing involvement of other countries. In recent years the annual meeting has been held outside of the United States every other year. In summer 2002, for example, the ISSS met in Shanghai, China, where there is a growing interest in systems thinking.[16]

Beginning in 1967 a number of academic programs in systems research were established. Those most closely associated with SGSR included: (1) the Systems Science Institute established by Miller at the University of Louisville in Kentucky, (2) the Department of Systems Science directed by George Klir at the State University of New York at Binghamton, (3) the Cybernetics Systems Program developed by William Reckmeyer at San Jose State University in California, (4) the Social Systems Science Program run by Russell Ackoff at the University of Pennsylvania in Philadelphia, (5) the Institute for Advanced Systems Studies, directed by Len Troncale at California State Polytechnic University, (6) the Systems Science Program at Portland State University in Oregon, (7) the Whole Systems Design Program established by Harold Nelson at the University of Antioch in Seattle, Washington, and (8) Saybrook Institute in San Francisco, California. Also beginning in 1967, task forces were established in the areas of education, organization and management, social systems, and health systems, reflecting a growing interest applying general-systems principles in a variety of organizational and societal contexts. The bylaws of the society were changed in April 1974 to support this shift in emphasis from a primarily theoretical to a more practical orientation.[17]

A particularly interesting development, harkening back to Mead's comment at the organizational meeting in Atlanta, was a growing desire among the membership for a more open, participatory format at the annual meetings. The April 1973 issue of the *General Systems Bulletin* addressed the concept of the SGSR as an open system. An analysis of the society's processes by its members concluded that "homeostasis is not enough." Referring to Russell Ackoff's emerging critique of the traditional approach in operations research and management science, the article pointed out that "modern professional organizations are groping for ways to accommodate varying points of view and changing parameters of participation." A second article, "A Systems Critique of the 'General Systems' System," argued that "the rumblings of discontent at SGSR meetings suggest the need for providing opportunities for feedback," asking what interests were currently being served by systems theory and whether it was ultimately a revolutionary or reactionary force.[18]

In response, the SGSR implemented changes in its organizational structure as well as in the format of the annual meetings to address the membership's desires. At the 1977 meeting in Denver, several "interaction modes" were incorporated into the program. Commenting on their success and addressing additional innovations for the upcoming 1978 annual meeting, Richard Ericson wrote, "All in all, we continue to strive to create new formats which may evoke learning experiences rather different from those available in more traditional program structures." The 1979 Silver Anniversary Meeting in London, in addition to enhancing the international visibility of the society, aimed to "demonstrate that academic and professional conferences could be devised so as to make them inherently productive and creative experiences for those who participated." Included as part of the program was a "metaconference," an attempt to create a "truly participatory democracy aided by communications and computer technology as well as a population actively engaged in the process of becoming informed."[19]

These concerns with self-reflection and self-correction, along with an increasing emphasis on process, would become a hallmark of more recent work in systems thought, reflected in Heinz von Foerster's definition of second-order cybernetics as the cybernetics of *observing* systems in contrast to first-order cybernetics, which was concerned primarily with *observed* systems. As one of the participants in the original Macy conferences on cybernetics, von Foerster was involved in the American Society for Cybernetics (ASC) that was officially established in 1964. While initially separate from SGSR, Mead being one of the few who was actively involved in both organizations, several members of the ASC, including Stafford Beer, Gordon Pask, and von Foerster, joined SGSR in the 1970s, when the ASC became temporarily inactive.[20]

VARIATIONS ON THE GENERAL-SYSTEMS THEME

In their introduction to the 1957 yearbook, the editors wrote: "General systems theory means many different things to different people," going on to explain that the primary aim of the society was to provide a forum and "a vehicle of communication for the various points of view." In the December 1970 *Bulletin,* F. K. Berrien describes GST as "not an explanation but a way of thinking about many, but by no means all, the social issues which trouble many people in this revolutionary period." Referring to Ross Ashby's suggestion that all intelligent systems are selective and that "information that does not fit into meaningful constellations has a way of being ignored or discarded," Berrien remarks that "it has been my experience that I discard less, and find sense in more varied places with this orientation than with any other," emphasizing the ability of GST to foster connections between very diverse disciplines. In his 1979 presidential address, Ericson defines the purpose of general-systems research as the "creation of an intellectual and spiritual milieu such that persons from all disciplines are able meaningfully to interact, thus promoting inter- and trans-disciplinary outcomes, . . . [as well as] an environment in which there is a release of imagination and creative thought, yielding new perceptions of ways to deal with micro-system-constrained problems." Milton Rubin, president of SGSR in 1968, suggested that the society might provide a forum for both systems and antisystems perspectives—a meeting-ground for conservative and liberal, right and left, reducing or perhaps absorbing some of the traditional antinomies in that between system and antisystem.[21]

Given the tremendous range of disciplines included under the umbrella of GST, however, conceptions of what it actually entailed varied considerably. Boulding often distinguished between *special* general systems and *general* general systems, the former dealing primarily with mathematical and computer models, and the latter a more philosophical orientation focusing on the "perception of structural similarities in different parts of the empirical world." While he remarked that the philosophical branch was closer to the original conception of GST, he suggested that "special" general systems "may have turned out to be more practically useful."

Within the philosophical approach, he distinguishes further between Miller's primarily physiological orientation and his own evolutionary and ecological conception of GST. While Miller identified essentially the same nineteen to twenty subsystems at every level of organization, Boulding's model recognized a higher order of complexity at the symbolic and social levels of organization because of the greater significance of information and knowledge.[22]

Another common distinction, especially in relation to the management dimension of systems thought, was described in terms of "hard" and "soft" approaches to systems analysis, the first referring to more instrumentally oriented concerns, and the latter concerned primarily with values and the decisionmaking process. George Klir, a former president of the society (1981), identifies systems modeling as the central problem in systems science, while West Churchman, another former president (1989), sees ethics and management as primary. Some have tried to incorporate both aspects in a synthesis of both technological and ethical concerns. Hal Linstone, president in 1993, suggests that there are three critical factors to consider in any situation involving the interaction between humans and technology: the technical, the organizational, and the personal. Similarly, Zinchang Zhu has developed a model based on the three aspects of *wuli, shili,* and *renli,* dealing respectively with investigating and modeling objective existence, studying ways of seeing and doing, and managing human relations.[23]

In his introduction to the proceedings of the 1976 annual conference, Jay Dixon White argues that GST should be Janus-faced, noting that the collection of papers addressed both theoretical and practical concerns: "Such participants as Anatol Rapoport, Kjell Samuelson, and Alfred Kuhn show a concern for the validity and utility of GST as a conceptual system in itself. On the other hand, . . . Kenneth Boulding, Kenneth Watt, and John Milsum dealt with GST as it may be applied to the dissolving of real world problems." The 1977 annual conference emphasized the diversity of topic areas "within the general systems frame of reference. . . , rang[ing] from second-order cybernetics and theories of self-organization to the application of systems concepts in social, managerial, information, and ecological systems."[24]

Regarding the relationship between GST and cybernetics, Ericson notes that some tend to see them as equivalent, while others perceive an evolutionary progression from "classical" GST, as defined by Bertalanffy, to cybernetics, information theory, and structuralism. He suggests that such conceptions "miss the spirit of general systems research as manifested in the Society and its annals," and, further, that it is useful to differentiate the general-systems approach from both cybernetics and systems analysis. Referring to Boulding's typology of systems, he writes, "Cybernetic and even 'open' systems are subsumed by the 'general systems framework' which comprises all nine levels of systems he identifies." In addition, he remarks that the term "cybernetics" conjures images "far from the essence of what most of us, I believe, understand by general systems." On the other hand, Stafford Beer writes that "Bertalanffy denied the identity of GST and cybernetics only by delimiting the definition of the latter in a way which is probably too restrictive."[25]

In the spirit of second-order cybernetics, however, SGSR was increasingly concerned with the nature of the knowledge process. The 1983 annual conference addressed the relationship between global problems and the "knowledge environment," in terms of such issues as "the role of intellect in cultural evolution, the effects of computer systems on the knowledge environment, and the impact that changes in the accessibility of information have on the general public, on the individual person, and on the society as a whole." Walter Buckley, a sociologist with a general-systems orientation, writes that an adequate understanding of the structure and dynamic processes of complex sociocultural systems requires an appreciation of "the microprocesses underlying the macrolevel." Addressing the "social contruction of reality" and the role of language as "mediator, if not creator, of such constructions and interpretations," he argues for a transactional model of the knowledge process as an information-processing system, with both morphogenic (structure-changing) as well as morphostatic (structure-preserving) capabilities: "Knowledge is not passively and finally given merely through information input to the sensory apparatus, but rather is actively constructed and reconstructed through continual interchange between the individual and his physical and social environment."[26]

As a result, Buckley suggests that traditional approaches to epistemology and ontology "are seriously incomplete and deficient" since they tend to focus on only one or two aspects of the total system. Addressing such approaches as empiricism, idealism, phenomenology, logical atomism, and "varieties of positivism," he argues that all of them tend to ignore at least some aspects of "the sequence from information inputs from an assumed (or studiously denied) external world to the sensory apparatus, to its transformation into sensations, sense data, or percepts, and then to mental phenomena, concepts, ideas, images, or language and logical symbols." Based on the concepts of information theory, he suggests that "the essence of information is the *pattern* or *organization* of the signal elements," and thus that information transmission involves the "preservation of pattern over transformations." He also points out that both information and meaning are "inherently relational," mediating between the structure of the nervous system, the individual human organism as a purposeful being, and its ecological, sociocultural, and technological environment. Further, addressing the structure of neural networks, he writes: "The analysis of the nervous system as a complex of nerve nets processing data in the manner of logic circuits, with the higher centers acting to coordinate the various kinds of information from peripheral processes and from memory storage and to integrate it into plans, decisions, and action, gives us a rather definite picture of a *construction,* rather than mere reproduction process."[27]

Echoing this theme in his introduction to the proceedings of the 1968 annual conference, Milton Rubin asks, "Where does social system exist—is it not only a network of relationships that exist only in our minds." Increasingly, the annual meetings tended to focus predominantly on urban and environmental problems. Rubin writes that there was an appreciation of the "social universe as part of the ecological system," going on to explain that "the term ecological system emphasized viewing things in a context, like the logical category of Aristotle called 'habitus,' the thing in context." Even more interesting in light of tendencies to portray systems views as reinforcing uniformity, Rubin suggests that "society might benefit by encouragement of groups with independent cultures for the development of differing types of individuals, as compared to the present international tendency to homogenize manufacturing processes, products, cultures, and personality types." Reflecting this concern with the preservation of diversity, the Special Task Force, established in 1978 to evaluate the evolution of GST over the previous twenty-five years, acknowledged "the extreme diversity of interests which are represented by the Society," and sought to assure that all such interests be reflected in the final report of the task force.[28]

TOWARD PARTICIPATORY AND EMANCIPATORY MODELS

For many members of SGSR, the emphasis on participatory process was a natural extension of their conception of systems. While the initial focus of the society was primarily theoretical, the central concern with problems of complex social and technological systems led to an increasing emphasis on questions of systems design and management. Brian Gaines, president of SGSR in 1979, describes a shift in approach from control to participation, which he sees as technically founded in systems theory and psychosocially grounded in the critical theory of the Frankfurt school. This shift is reflected in the contrast between "societies in which you enforce policies by the manipulation of behavior and societies in which you generate the same behavior by presenting the logic of the situation to its members in such a way that they act in the required manner of their own volition." While the latter approach still lends itself to manipulation and co-optation by the powers that be, it gives the members a slightly more active role in the decisionmaking process. Gaines cites the work of Gordon Pask, president in 1974. Using the terminology of Jürgen Habermas, Pask distinguishes between "technical cognitive" and "emancipatory cognitive" approaches to learning and behavior. In the first model, the learner is "a behavioral object to be manipulated," while in the second s/he is "an equal partner."[29]

The transition from manipulative to participatory conceptions of management can be seen most clearly in the evolution from the initial "hard" systems approaches of the 1940s and 1950s to the interactive and "soft" systems approaches represented in the work of Russell Ackoff and Peter Checkland (presidents of SGSR in 1987 and 1986, respectively), and the more recent "critical" systems approach based on the work of Werner Ulrich, Michael Jackson, and Robert Flood. Jay Forrester, whose work provides the foundation for the "system dynamics" school of systems thought, also represents a move away from the traditional approach of operations research. Forrester's work focuses primarily on the use of formal models to simulate the nonlinear dynamics of interaction between multiple variables, although it has inspired broader analyses of values, beliefs, and behavior—in Peter Senge's work on organizational learning, for example. Another influential development along these lines is Stafford Beer's work on management cybernetics and the "viable systems model," which is described as "a tool for understanding our socially constructed realities." Both Forrester and Beer contributed significantly to the evolution of general-systems thought, although Forrester and the System Dynamics Society were never formally associated with SGSR. Beer, on the other hand, was president of SGSR in 1971 and actively involved with the ASC, whose membership overlapped to some extent with that of the SGSR.[30]

The evolution of these various strands of thought is documented in a special double issue of the *System Dynamics Review.* Acknowledging a lack of communication between the various communities, which the special issue was intended to address, George Richardson quotes the following lines from Alfred Lord Tennyson, as "an apt description of the burgeoning state of today's systems thinking communities":

> I know that age to age succeeds,
> Blowing a noise of tongues and deeds,
> A dust of systems and of creeds

The transition from hard- to soft-systems thought and practice, along the lines of Ackoff and Checkland, is comprehensively addressed in a collection of papers from the 1994 annual meeting of the United Kingdom Systems Society. Amanda Gregory describes this evolution in thinking in terms of the models used to evaluate organizations, beginning in the 1950s when the emphasis was on the ability of the organization to achieve its goals. In the 1960s the emphasis shifted to its ability to adapt and survive in a dynamic environment; in the 1970s, to satisfy the needs of all involved parties; and in the 1980s, to facilitate the development of its members and enhance its internal variety.[31]

The hard systems approach focuses primarily on improving the efficiency of technological systems, with a basically instrumental view of their human components, while the soft systems approach incorporates a consideration of the role of values and world views in complex systems in which human beings play essential roles. Hard systems approaches are generally characterized as objectivist, positivist, nomothetic, functionalist, reductionist, and innately conservative. In contrast, the soft systems approach builds on the interpretive model of Max Weber, emphasizing the subjectivity of the human participants. Based on the assumption that reality is socially constructed, it challenges the narrow application of scientific method to the social world. Because human experience comprises multiple realities, the emphasis is on the need for building a shared understanding, through participatory involvement in decisionmaking. Perhaps one of the most important reasons for this shift was the dramatic failure of hard systems approaches in social contexts. Bertram Gross, president of SGSR in 1970, points out that systems analysis and operations research were "oversold beyond [their] sphere of relevance."[32]

David Lane notes that while social scientists tend to associate systems theory with functionalism, soft-systems theorists identify themselves with the interpretive tradition. Lane refers to Gibson Burrell and Gareth Morgan's two-dimensional scheme of sociological thought, with a horizontal axis representing the relative emphasis on the objective or subjective aspects of social organization and a horizontal axis representing the spectrum in orientation from regulation to radical change. Although systems theory is often understood in objective and regulatory terms, as a tool for preserving the status quo, recent developments in the tradition of critical-systems theory identify themselves explicitly as emancipatory, in the tradition that Burrell and Morgan refer to as "radical humanism." They distinguish radical humanism, with its subjective focus on the liberation of individual human beings, from radical structuralism, which emphasizes structural conflict. While hard operations research is characterized by "deskilling, centralization, and control," the more recent softer varieties emphasize "reskilling, decentralization, and liberation."[33]

C. West Churchman, president of SGSR in 1989, was closely associated with Ackoff and, though not actively involved in SGSR until the 1980s, he had a significant impact on the evolution of soft-systems thinking within the general-systems community. He and Ackoff were both involved with the establishment and development of the fields of operations research and management science, publishing an introductory text on the former in 1957. Robert Flood and Michael Jackson describe Churchman as "one of the best known and respected scholars in the systems field." In his evolution from operations research to a critical analysis of modes of inquiry, he becomes "the conscience of the systems movement, striving to engender a strong focus on morality and a continuing attention to the needs of people." In a 1970 article entitled "Operations Research as a Profession," Churchman proposed the incorporation of a critical Kantian base in systems thought and developed a technique he called "Strategic Assumption Surfacing and Testing" (SAST), specifically for groups that do not share a common set of values and goals, to help participants identify their own assumptions and world views, and understand different points of view.[34]

Echoing Churchman's critique of the impoverished view of human nature embodied in traditional approaches to operations research, both Ackoff and Checkland sought to enrich the ethical foundations of systems practice. Ackoff's work reflects a departure from the traditional role of consultants as expert planners for organizations to one as facilitators of communication and understanding among interacting participants. He saw the ideals of optimization, prediction, and control, central to the project of operations research, as outdated, and sought to replace them with an interactive approach to management, reflecting what he saw as a shift from mechanistic to organismic and finally to a fully social view of human systems. Such a view underscores the necessity of a synthetic rather than an analytic approach to problem solving, especially given the complex "messy" nature of social problems.[35]

Ackoff's interactive approach was further developed in the "soft systems methodology" (SSM) of Peter Checkland. Suggesting that most problems arise in environments where people have different values, based on particular images of the world, Checkland was one of the first to popularize the distinction between hard and soft systems approaches. In contrast to the hard systems approach, with its emphasis on modeling and quantitative analysis, SSM focuses on the clarification of values and perceptions, based on the idea that "social reality is not a given but is a process in which an ever-changing social world is continuously re-created by its members." Checkland acknowledges Geoffrey Vickers's concept of the "appreciative system" as an important contribution in the evolution of his own views, moving beyond the traditional conception of organizations as goal-seeking machines to an appreciation of their relationship-maintaining aspects. Based on Weber's suggestion that human actions depend upon the meaning that they ascribe to their situation, SSM embodies a learning approach, highlighting considerations of values and culture, seeking to structure debate about different ways of understanding the situation, and accommodating conflicting perspectives regarding desirable goals.[36]

Checkland introduces the concept of the "human activity system," which can not be understood in purely mechanistic terms. He describes his soft systems methodology as a set of tools for "coping with complexity, uncertainty and conflict" and for fostering more inclusive participation among stakeholders, that is, all individuals who are affected by a particular decision. He sought to develop epistemological rather than ontologically based models that were to be understood as "subjective intellectual constructs" rather than objective representations of the real world. While "hard" operations research assumes that problems are well defined and organizational objectives clear, in the soft-systems approach the traditional goals of solution and optimization are no longer meaningful, giving way to the aim of "help[ing] participants learn together about their problem area."[37]

Bela Banathy draws on Checkland's concept of the human activity system in his work on the design of educational and social systems. He emphasizes the "necessity of a comprehensive involvement of the community in the design of new systems as 'user-designers,' and therefore a recognition of the limited role of the 'expert.' " He also identifies different types of human activity systems (rigidly controlled, deterministic, purposive, heuristic, and purposive-seeking) based on how much freedom the system has to select its own purpose, goals, methods, and tools, and how widely this freedom is distributed (or concentrated) in the system. Banathy initiated the International Systems Institute, which holds annual "conversations" on the art and practice of participatory or "systemic" design. His work has contributed to a growing tendency within the systems community to distinguish between such "systemic" approaches and more traditional "systematic" approaches. Robert Flood, for example, writes that "the principle of meaningful participation follows the *systemic* principle."[38]

Checkland's work also raises the question of how to create information systems based on the soft-system model of human activity systems. As an essential factor in the creation and reinforcement of organizational structure, information systems provide a point of contact between the hard and soft approaches. The field of information systems deals with the role of computers as tools for enhancing communication, solving problems through the dissemination of knowledge, incorporating individual differences in perspective, and encouraging interactive response. Information-systems theorists suggest that computer networks have the potential to flatten traditional hierarchies. To some extent, the evolution of information systems reflects changing models in organizational theory, with a corresponding shift from hierarchical to "heterarchical" (i.e., many centers of power) models, emphasizing decentralization, autonomy, and flexibility, as well as collaborative leadership and increasing access to data.[39]

In practice, the participatory ideal of SSM often fails to be realized. Lane suggests that SSM lacked a political stance and tended to conserve and support rather than challenge the status quo. This view is reflected in a number of critiques from within the systems community itself, arguing that Checkland's approach does not provide a way of ensuring the inclusion of anything other than the managerial point of view, thus betraying its critical potential. Accommodation of conflicting interests often translates as accommodation to the prevailing power structure. The critical systems approach represents an attempt to expand the insights of the soft-systems approach, focusing more specifically on issues of power. While the soft-systems approach is restricted by the prevailing power structure, the critical-systems approach seeks to clarify the constraints of the existing system and to transform it. Although Checkland's work acknowledges the influence of Habermas, the critical approach takes more seriously his model of the "ideal speech situation," in which any assumption can be questioned and all viewpoints heard. It is specifically dedicated to the ideals of social justice, human emancipation, and the development of human potential. Mandy Brown makes a distinction between participation as means and participation as end, which is particularly helpful in this context. While the soft-systems approach emphasizes participation as means, the critical approach sees participation as end—thus its focus on the cultivation of essential social skills.[40]

In addition to the influence of Ackoff and Checkland, critical-systems thinking has roots in the "critical systems heuristics" of Werner Ulrich, an "approach for studying existing or planned systems by uncovering the interests that the system serves" and for seeking out "sources of motivation, control, expertise, and legitimation, . . . reveal[ing] underlying values of the system design, with the aim of exposing and freeing the design from individual, organizational, cultural, societal, and political value assumptions that may be hidden and coercive." Critical-systems approaches also place greater emphasis on critical self-reflection at every stage of inquiry. Norma Romm extends the role of the critical inquirer beyond mediation between stakeholders with different interests, to include support for the disadvantaged as the key client, reeducation of the elite, and the development of methods that enable the surrender of control. While researchers and facilitators are considered as participants in this process, she acknowledges that the danger of imposing their own values and assumptions remains. Robert Flood's concept of "total system intervention" involves the complementary use of hard, soft, and critical approaches, addressing issues of control in the dimensions of organizational processes, design, culture, and politics. Reflecting a commitment to methodological pluralism, his model incorporates careful examination of the assumptions and ideological commitments of different methodologies. However, the notion of total system intervention, along with the definition of systems practice as "intervention in society intended to bring about improvement," highlights the ambivalence of the systems practitioner's role in such attempts to change the values and orientation of management.[41]

Tony Brauer discusses the problem of imposing ideas of emancipation, empowerment, and liberation on others. Jane Young writes about the difficulties of encouraging participation in cultures where confrontation and an adversarial stance are the norm. These concerns are illustrated particularly well in Margaret Barrett and Barry Crellin's discussion of their efforts to introduce participative teaching methods in Poland, where formal and hierarchical relationships prevail. While these are serious challenges, there has clearly been an important transition in the conception of the systems analyst's role from expert to critically self-reflective facilitator of positive change in social organizations. S. K. Probert describes what he see as a growing cynicism among the systems community resulting from the conflict between the ideal of liberation and the necessary concessions to practice. More optimistically, Gillian Ragsdell recognizes the need for balancing the judgments of client and interventionist, while honoring the critical and reflective dimensions of the practitioner's role as more recently envisioned.[42]

CONCLUSION

This concern with critical self-reflection echoes Margaret Mead's suggestion, at the planning meeting in 1956, that the society examine itself from a systems perspective. The emphasis on the constant reevaluation of goals and assumptions is characteristic of SGSR and represents one of its most valuable contributions to the understanding and possible resolution of some of the problems facing the global community at the beginning of the twenty-first century. In his introduction to the collection of articles on the various strands of systems thought published in *System Dynamics,* Richardson notes that the journal had requested contributions addressing "the characteristics of systems thinking and systemic problem solving [with] the greatest promise for yielding applicable insights and improving policy and decision making in complex systems." While such a focus might underscore concerns of critics of systems thought, it also highlights the central importance of reexamining the nature of management and leadership in complex social and technological organizations, and raises the question of how to foster more inclusive decisionmaking processes. While it is easy to dismiss the efforts of these systems thinkers as misguided and self-serving, the SGSR has gone farther than most organizations to foster conversation on such issues across a broad spectrum of academic and occupational perspectives.[43]

In his report on SGSR, Roger Cavallo writes that "achievements along narrowly considered lines of systems engineering can only be enhanced by their embedding in the broader intellectual and cultural context of which they are a part," which of course includes consciously participating actors. He suggests that such a task reveals "three fundamental systemic problems: how to design and manage systems so they can effectively and efficiently serve (1) their own purposes, (2) the purposes of their purposeful parts, and (3) the purposes of the larger systems of which they are part." He refers to these problems in terms of self-control, humanization, and environmentalization, and then goes on to argue that "the deepest systems view implores science to confront the issues of 'being human.'" Science, he says, "needs a human model which subsumes the mechanical and organic models, contains substantially new features, and addresses the core of lived experience." Further, efforts to understand human systems call for a conversational method involving both the experimenter and the subject: "Individuals cannot be treated as objects, or be instructed in how to take part in an experiment without the recognition of the autonomy of each person and the invitation to participate jointly in co-operative exploration of the nature of man." Such an approach is far from the technocratic elitism that Lilienfeld decries. It is an important dimension in the evolution of the general-systems project that deserves further consideration.[44]

NOTES

1. Nilamadhab Kar and Brajaballav Kar, "Social Cognition and the Participatory Planning Process, *Systems Research and Behavioral Science* 19 (2002): 377. This article is from an issue of *Systems Research* devoted to "Participatory Planning and Design."

2. Kenneth Boulding, "Suggested Program for Work at the Center," March 9, 1954 (in Kenneth E. Boulding Collection, Bentley Historical Library, University of Michigan, hereafter KEB/MI, Box 26), pp. 1–2; Letter to Ralph Tyler, July 20, 1953 (KEB/MI, Box 5); Mimeographed questionnaire on specific seminars of interest to CASBS fellows; Bertalanffy, Mimeographed questionnaire (same as previous—both in KEB/MI, Box 26); Anatol Rapoport, "Statement," April 21, 1954 (KEB/MI, Box 26), p. 1.

3. Ralph Gerard, "Statement of Possible Activities at the Center," July 7, 1954 (KEB/MI, Box 26); Rapoport, "Statement," pp. 2–3; Ludwig von Bertalanffy, "A Program of Systems Research and Interdisciplinary Synthesis (KEB/MI, Box 29); Letter from Boulding to Bertalanffy, Nov. 25, 1953 (KEB/MI, Box 29); Letters from Bertalanffy to Boulding, Dec. 16, 1953, and Jan. 25, 1954 (KEB/MI, Box 29); Letter from Rapoport to Bertalanffy, June 7, 1954 (KEB/MI, Box 5).

4. Cynthia Kerman, *Creative Tension: The Life and Thought of Kenneth Boulding* (Ann Arbor: University of Michigan Press, 1974), pp. 45–46; Anatol Rapoport, *Certainties and Doubts* (unpublished English translation of autobiography, *Gewissheiten und Zweifel* [Darmstadt: Verlag, 1994]), ch. 8, pp. 1, 3–4. Lewis Richardson's work was published in 1960 in two volumes: *Arms and Insecurity: A Mathematical Study of the Causes and Origins of War* (Pittsburgh: Boxwood Press, 1960) and *Statistics of Deadly Quarrels* (Pittsburgh: Boxwood Press: 1960), the first edited by Rashevsky.

5. "Workshops," n.d. (KEB/MI, Box 26); "Report on General Systems Theory (Workgroup, Seminar, Society)," July 1955 (KEB/MI, Box 29), pp. 1–2; Ludwig von Bertalanffy, "General System Theory," *Main Currents in Modern Thought* 11 (1955): 75–83; Ralph Gerard, "Levels of Organization," *Main Currents* 12:5 (1956): 104–108.

6. "Report on General Systems Theory," pp. 2–3; Letter to Dr. Raymond L. Taylor, associate administrative secretary for the AAAS, signed by Bertalanffy, Boulding, Gerard, and Rapoport, Sept. 30, 1954 (KEB/MI, Box 5); "Announcement of Society for Advancement of General Systems Theory: Proposed Statement of Purpose," (KEB/MI, Box 29).

7. "Report on General Systems Theory," pp. 3–4; "Report on meetings held at AAAS," Dec 1954 (KEB, Box 29), pp. 1–2. An announcement about the formation of the society was included in Bertalanffy's article "General System Theory," published in *Main Currents in*

Modern Thought that March. The original membership list includes representatives from the disciplines of engineering, mathematics, chemistry, biology, anatomy, anthropology, medicine, education, psychiatry, sociology, law, economics, political science, history, philosophy, and industrial management, as well as from such institutions as the Carnegie Institute, the Universities of California, Chicago, Illinois, Iowa, Kansas, Michigan, Oregon, Washington, and Wisconsin, Harvard, Stanford, Yale, San Francisco State College, the Menninger Foundation, Michael Reese Hospital, Bell Telephone, Burroughs Corp., General Electric, and International Business Machines.

8. Milton Rubin, "Report on the 1969 SGSR Annual Meeting," *General Systems Bulletin* 2:1 (March 1970): 19; "Report on Organizational Meeting," Dec. 27, 1954 (KEB/MI, Box 29).

9. Kenneth Boulding, "Systems Research and the Hierarchy of World Systems," *Systems Research* 2:1 (1985): 10; "The Society for General Systems Research," n.d. (KEB/MI, Box 29—I have inserted the word "provide" to reflect what I understand as the intended meaning. I don't think they sought to *prevent* mutual reinforcement). Final quote from "The Boulding's Eye View," an unpublished paper in Kenneth Boulding Collection, University of Colorado, hereafter referred to as KEB/CU, Unpublished Papers).

10. Richard Ericson, "In Remembrance of Margaret," *General Systems Bulletin* 9:2 (winter 1979): 27. Margaret Mead was a participant in the Macy conferences on cybernetics and believed that the cybernetic approach was unique in incorporating the observer into the system being observed; see Stewart Brand, "A Conversation with Gregory Bateson and Margaret Mead," *CoEvolution Quarterly* 10 (1976): 34.

11. "Status of the SGSR" (KEB/MI, Box 29); Kenneth Boulding, "The Next Thirty Years in General Systems," *General Systems Bulletin* 15:1 (fall 1984), reprinted in *General Systems* 29 (1985): 3; Letter to Bertalanffy, March 13, 1957 (KEB/MI, Box 29), regarding Meier taking over as secretary.

12. *General Systems Bulletin* 9:2 (winter 1979): 3, 33; *General Systems Bulletin* 3:1 (May 1971): 51. See also *General Systems,* vols. I–XV (1956–1970).

13. *General Systems Bulletin* 25:3 (fall 1996): 3.

14. Kenneth Boulding, "Systems Profile: Some Origins," *Systems Research* 4:4 (1987): 287; "The Political Implications of General Systems Research," *General Systems* VI (1961): 1–7. In a letter to W. W. Cooper of the Institute of Management Science, March 1955 (KEB/MI, Box 5), addressing the relationship between GST and management science, Boulding writes: "I think that in many respects the interests of the two societies will overlap and I think this will be very profitable to explore the possible connections between them." Rapoport, among others, was less enthusiastic about this association, although his sympathies changed as he gained an appreciation for some of the more progressive developments in the management field.

15. Kenneth Boulding, Letter to Charles McClelland, Nov. 24, 1958 (KEB/MI, Box 29). McClelland was chairman of the Division of Social Science at San Francisco State College.

16. SGSR Newletter, March 1959 (KEB/MI, Box 29); *General Systems Bulletin* 1:1 (Dec. 1969): 1–2; *General Systems Bulletin* 2:2 (June 1970): 19; *General Systems Bulletin* 3:1 (May 1971): 20, 34–36; *General Systems Bulletin* 5:1 (autumn 1974): 20; Flyer on SGSR, Dec. 1984 (KEB/CU, "Society for General Systems Research"). Those active in the London chapter included Gordon Pask, Brian Gaines, and Geoffrey Vickers.

17. *General Systems Bulletin* 3:1 (May 1971): 51; *General Systems Bulletin* 4:2 (Sept. 1973): 3; *General Systems Bulletin* 7:2 (winter 1977): 25; *General Systems Bulletin* 8:1 (Aug. 1977): 1; William Reckmeyer, "The Current Nature and Scope of General Systems Educa-

tion," n.d. (manuscript from author); Donald McNeil, "Report on Systems Approaches: Preliminary Draft," March 29, 1996 (manuscript from author), pp. 9–12. Hal Linstone, president of SGSR in 1993, was involved in the planning of the Portland program. This is by no means an exhaustive list of educational programs, and includes only those established in the United States. Numerous programs were established in Europe, especially in the United Kingdom. Klir was the editor of the *International Journal of General Systems,* founded in 1974, at about the same time that Miller's *Behavioral Science* also became an official publication of SGSR.

18. *General Systems Bulletin* 3:1 (May 1971): 23; *General Systems Bulletin* 3:2 (Dec. 1971): 35; *General Systems Bulletin* 4:1 (April 1973): 21, 32.

19. Richard Ericson, ed., *Avoiding Social Catastrophes and Maximizing Social Opportunities: The General Systems Challenge* (Proceedings of the 22nd Annual Meeting, Washington, DC, 1978); Richard Ericson, ed., *Improving the Human Condition: Quality and Stability in Social Systems* (Proceedings of 1979 Silver Anniversary Meeting, London), p. xii; *General Systems Bulletin* 10:1 (autumn 1979): 16.

20. Heinz von Foerster, ed., *Cybernetics of Cybernetics: The Control of Control and the Communication of Communication* (Urbana: Biological Computer Laboratory, University of Illinois, 1974), p. 1. The subtitle of this compilation of articles on cybernetics extends Wiener's original definition of cybernetics in terms of control and communication. The ASC grew out of a series of informal luncheon meetings among the original cybernetics group. Under the leadership of Warren McCulloch, it was primarily concerned with understanding the nature of knowledge by studying the nervous system, in contrast with the SGSR's more interdisciplinary focus on a general theory of systems. According to Stuart Umpleby, former president of ASC, the initial impetus for the formation of the society came from the government, concerned about a "cybernetics gap" with the Soviet Union. In fact, he suggests further, that the Macy Foundation was occasionally a conduit of funds from the Central Intelligence Agency. The ASC was reestablished in 1980, under the leadership of Barry Clemson and Umpleby, with greater emphasis on second-order cybernetics, and the ASC and SGSR retained a certain affiliation through common membership (E-mail, March 19, 1997, and April 7, 1997).

21. Richard Ericson (citing first yearbook), "SGSR at 25: What Agenda for Our Second Quarter Century," Reprint of Presidential Address from 1979 Annual Conference, *General Systems Bulletin* 9:2 (winter 1979): 30, 41; Kenneth Berrien, "Social Systems, Adaptation, and Personality," *General Systems Bulletin* 2:3 (Dec. 1970): 2; Milton Rubin, "The General Systems Program: Where Are We Going?" in Milton Rubin, ed., *Man in Systems,* Proceedings of 1968 Annual Conference in Dallas (New York: Gordon and Breach, 1971), p. 4.

22. Boulding, "The Next Thirty Years," p. 3; "Systems Profile," p. 287. In his introduction to a collection of papers on GST, George Klir writes, "The comparison of individual conceptual frameworks used in individual approaches to GST appears to be very difficult." He identifies eight different ways of defining GST: (1) formal theory, (2) a way of thinking, (3) a methodology, (4) a way of looking at the world, (5) a search for optimal simplification, (6) a metalanguage, (7) an educational tool, and (8) a profession, in "Preview: The Polyphonic GST," in George Klir, ed., *Trends in General Systems Theory* (New York: Wiley, 1972), pp. 14–15.

23. Klir, "Preview," pp. 2–3; Churchman (personal interviews, 1994–1995); Harold Linstone, *The Challenge of the 21st Century: Managing Technology and Ourselves in a Shrinking World* (Albany: State University of New York, 1994). Ida Hoos, who wrote a scathing critique of earlier applications of systems analysis in management in *Systems Analysis in Public Policy: A Critique* (Berkeley: University of California Press, 1972), writes

in her foreword to Linstone's book that he "analyzes the shortcomings and pitfalls of systemic approaches that may have had iatrogenic effects in the long run," and that he "argu[es] persuasively for a new multi-perspective paradigm, . . . that encourages unbounded thinking and ethical action" (Hoos, in Linstone, *The Challenge of the 21st Century,* p. xvi). Zinchang Zhu's model was discussed in E-mail distributed by the ISSS Primer Group, which is one of many "special integration groups" that have emerged within SGSR/ISSS over the last forty years. Zhu is associated with the Institute of Systems Sciences in Beijing, China.

24. Jay Dixon White, ed., *General Systems Theorizing: An Assessment and Prospects for the Future,* SGSR Conference Proceedings (Boston, 1976), p. i; *The General Systems Paradigm: Science of Change and Change of Science,* Conference Proceedings (Denver, 1977), p. i.

25. Ericson, "SGSR at 25," pp. 28–29; Stafford Beer, "GST," in von Foerster, *Cybernetics,* p. 32. Beer goes on to suggest that "the objectives of the SGSR, founded in 1954, would certainly have had the agreement of the early cyberneticians in 1942. On the other hand, they may be more general than some scientists (notably in the USA and France) would allow to cybernetics today."

26. Walter Buckley, "A Systems Approach to Epistemology," in George Klir, ed., *Trends in General Systems Theory* (New York: Wiley, 1972), pp. 188–189, 200; also George Lasker, ed., "Preface," *The Relation Between Major World Problems and Systems Learning* (Vol. 1: *The Ecology of Human Knowledge and Global Problems in Systems Perspective;* Vol. 2: *Advances in Holistic Problem Solving and Human Action Systems Research*), Conference Proceedings (Detroit: SGSR, May 1983; no page numbers in preface).

27. Buckley, "A Systems Approach to Epistemology," pp. 190–193 (emphases in original).

28. Milton Rubin, ed., *Systems in Society,* Proceedings (Boston, 1969), p. vii; "The General Systems Program," p. 13; Roger Cavallo, "Status of Special Task Force Report," *General Systems Bulletin* 9:1 (autumn 1978): 16.

29. Brian Gaines, "Progress in General Systems Research," in George Klir, ed., *Applied General Systems Research: Recent Developments and Trends* (New York: Plenum Press, 1978), pp. 18–19. Gaines cites Gordon Pask, *Conversation, Cognition, and Learning* (Amsterdam: Elsevier, 1975), and Jürgen Habermas, *Knowledge and Human Interests* (London: Heinemann, 1972). Habermas is one of the younger members of the Frankfurt school, based on the critical theory of Max Horkheimer and Theodor Adorno. There have been extensive debates on critical theory and systems theory between Habermas and Niklas Luhmann, whose conception of systems theory is derived from Parsons and the more recent epistemological concerns of Humberto Maturana and Francisco Varela. Maturana and Varela's work has been particularly influential in connection with second-order cybernetics; see Steve Heims, *Constructing a Social Science for Postwar America: The Cybernetics Group* (Cambridge, MA: MIT Press, 1991), pp. 283–284; and Humberto Maturana and Francisco Varela, *Autopoiesis and Cognition: The Realization of the Living,* Boston Studies in the Philosophy of Science, vol. 42 (Boston: D. Reidel Pub. Co., 1980).

30. George Richardson, "Introduction: System Thinkers, Systems Thinking," *System Dynamics Review: The Journal of the System Dynamics Society* 10:2–3 (summer–fall 1994): 96–98. See Peter Senge, *The Fifth Discipline: The Art and Practice of the Learning Organization* (New York: Doubleday, 1990). Richardson notes that Forrester emphasized formal modeling as "the only reliable foundation for policy decisions in complex dynamic systems" (p. 98). For further background on Forrester's work, see George Richardson, *Feedback Thought in Social Science and Systems Theory* (Philadelphia: University of Pennsylvania

Press, 1990), especially pp. 159–160. For background on Beer, see Roger Harnden, ed., *How Many Grapes Went into the Wine: Stafford Beer on the Art and Science of Holistic Management* (New York: Wiley, 1994); Stafford Beer, *Platform for Change* (New York: Wiley, 1975) and *Designing Freedom* (Toronto: Canadian Broadcasting Corporation, 1974). Beer's work contributed substantially to the evolution of general-systems thought and practice, although a more in-depth analysis is beyond the scope of this project. He is particularly noted for his efforts to establish a participatory-systems model in association with Salvador Allende in Chile.

31. Richardson, "Introduction," p. 95; Amanda Gregory, "Critical Reflections on the Past, Present, and Future Development of Organisational Evaluation," in Keith Ellis et al., eds., *Critical Issues in Systems Theory and Practice* (New York: Plenum Press, 1995), p. 480. See also Robert Flood and Michael Jackson, eds., *Critical Systems Thinking: Directed Readings* (New York: Wiley, 1991), p. 1, for an overview of the evolution of systems thought from the 1950s to the 1980s. Portions of the following discussion of soft- and critical-systems approaches are drawn from my review of K. Ellis, A. Gregory, B. R. Mears-Young, and G. Ragsdell, eds., *Critical Issues in Systems Theory and Practice* (1995), in *Systems Practice* 11:2 (1997): 218–222.

32. David Lane, "With a Little Help from Our Friends," *System Dynamics Review* 10:2–3 (summer–fall 1994): 104–105; Bertram Gross, "General Systems Framework for Urban Model-Building," *General Systems Bulletin* 2:1 (March 1970): 1. See Bridget Mears-Young, "Logistics Awareness: Vision Versus Practice," and R. T. Vigden and J.R.G. Wood, "Information Systems Development: Methods, Modeling and Metaphors in an Object-Oriented World," both in Keith Ellis et al., eds., *Critical Issues in Systems Theory and Practice* (New York: Plenum Press, 1995), pp. 577–583, 411–415. Gross notes that the worst abuse of systems analysis was the PPBS budgeting model, the focus of much of Ida Hoos's critique. See Bertram Gross, "The New Systems Budgeting," *Administration Review* (March–April 1969); and Ida Hoos, *Systems Analysis*.

33. Lane, "A Little Help," pp. 111–114. Lane cites J. Rosenhead, "Introduction: Old and New Paradigms of Analysis," in J. Rosenhead, ed., *Rational Analysis for a Problematic World* (New York: Wiley, 1989). See G. Burrell and G. Morgan, *Sociological Paradigms and Organizational Analysis: Elements of the Sociology of Corporate Life* (Aldershot, England: Gower, 1979). Lane locates critical theory, specifically the work of Jürgen Habermas, in the radical humanist tradition.

34. C. West Churchman, Russell Ackoff, and Leonard Arnoff, *Introduction to Operations Research* (New York: Wiley, 1957); Flood and Jackson, *Critical Systems Thinking,* pp. vii–viii, 3; Lane, "A Little Help," p. 110; C. West Churchman, "Operations Research as a Profession," *Management Science* 17 (1970), reprinted in Flood and Jackson, *Critical Systems Thinking,* pp. 19–40. See also C. West Churchman, *The Systems Approach* (New York: Dell, 1979), for discussion of SAST; *Challenge to Reason* (New York: McGraw-Hill, 1968); and *The Design of Inquiring Systems* (New York: Basic Books, 1971). Churchman and Ackoff were both founding members of the Operations Research Society and the Institute of Management Science. Churchman spent most of his career in the Department of Business Administration at the University of California at Berkeley, although in later years he taught courses in the Peace and Conflict Studies Program. Ackoff was associated in early years with the Case Institute of Technology and, later, with the Institute for Interactive Management in Philadelphia as well as the Social Systems Science Program at the University of Pennsylvania. Churchman was responsible for the publication of Boulding's article "General Systems Theory: The Skeleton of Science," in *Management Science* 2:3 (April 1956), so he was familiar with the development of general-systems thought.

35. F. R. Janes, "Interactive Management: Framework, Practice, and Complexity," in Keith Ellis et al., eds., *Critical Issues in Systems Theory and Practice* (New York: Plenum Press, 1995), pp. 51–60; Flood and Jackson, *Critical Systems Thinking,* p. 3; Richardson, "Introduction," p. 97. Recent work on the concept of interactive management can be seen in John Warfield, "Principles of Interactive Management," *Proceedings of the International Conference on Cybernetics and Society* (New York: IEEE, 1984), which focuses on methods for group decisionmaking. See also John Warfield, *Understanding Complexity: Thought and Behavior* (Palm Harbor, FL: Ajar Publishing, 2002).

36. Lane, "A Little Help," p. 97; Peter Checkland, *Systems Thinking, Systems Practice* (New York: Wiley, 1981), pp. 17–20; David Lane, "Systems Theory and Management Thinking," Martin Hall, "Merging the World of Systems Science and Human Values: The Organizational Perspective," and M. G. Haynes, "Soft Systems Methodology," all in Keith Ellis et al., eds., *Critical Issues in Systems Theory and Practice* (New York: Plenum Press, 1995), pp. 1–14, 131–135, 251–257. See also Peter Checkland, *Soft Systems Methodology in Action* (New York: Wiley, 1990). Checkland cites Geoffrey Vickers, *The Art of Judgment* (London: Chapman and Hall, 1965).

37. Lane, "A Little Help," pp. 105, 108.

38. Bela Banathy, "Comprehensive Systems Design in Education," *Educational Technology* (March 1991): 33; *A Systems View of Education* (Englewood Cliffs, NJ: Educational Technology Publishers, 1992), pp. 11–13. Robert Flood, "Total Systems Intervention: Critical Success Factors for a Systems Based Problem Solving System," in Keith Ellis et al., eds., *Critical Issues in Systems Theory and Practice* (New York: Plenum Press, 1995), p. 21 (my emphasis).

39. Kevin Doyle, "Uniting Systems Theory with Practice," Judy McKay and Peter Marshall, "Incorporating Individual Differences in Perspective in a Systemic Approach to Information Systems Requirement Analysis," Kim Merchant and Steve Clarke, "A Framework for the Design and Implementatation of Distributed Information Systems," and Richard Kamm, "Information Use in the 'New' Organization," all in Keith Ellis et al., eds., *Critical Issues in Systems Theory and Practice* (New York: Plenum Press, 1995), pp. 297–302, 387–393, 329–333, 315–321. Banathy's son, Bela A. Banathy, focuses on information systems, in addition to facilitating the annual Asilomar Conversation and coordinating a graduate program in systems at Saybrook Institute in San Francisco.

40. Quote from Lane, "A Little Help," pp. 108, 113–114; Mandy Brown, "The Ambiguities in Our Understanding of Participation and the Implications of This for Methodology," in Keith Ellis et al., eds., *Critical Issues in Systems Theory and Practice* (New York: Plenum Press, 1995), pp. 101–107. See Werner Ulrich, *Critical Heuristics of Social Planning: A New Approach to Practical Philosophy* (Bern, Switzerland: Haupt, 1983); Bridget Mears-Young, "Logistics Awareness," Gilbert Mansell, "Systems, Rationality and Equity in a Post-Modern World," M.W.J. Spaul, "An Ethical Basis for Critical Systems Thinking," R. Garcia and S. Motta, "The Critical Systems Thinking as a Path for Acknowledging Human Dignity in the Organizations," and Gerald Midgley, "What Is This Thing Called Critical Systems Thinking?" all in Keith Ellis et al., eds., *Critical Issues in Systems Theory and Practice* (New York: Plenum Press, 1995), pp. 577–583, 493–497, 511–516, 121–124, 61–71; also Michael Jackson, "Critical Systems Thinking: Beyond the Fragments," *System Dynamics Review* 10:2–3 (summer–fall 1994): 233, regarding the influence of Habermas in the evolution of soft- and critical-systems thought; and Jürgen Habermas, *Communication and the Evolution of Society* (Boston: Beacon Press, 1979).

41. Flood, "Total Systems Intervention," Norma Romm, "Some Anomalies in Ulrich's Critical Inquiry and Problem-Solving Approach," Jennifer Wilby, "Operationalizing TSI:

The Critical Review Mode," and Gilbert Mansell, "Systems, Rationality, and Equity in a Postmodern World," all in Keith Ellis et al., eds., *Critical Issues in Systems Theory and Practice* (New York: Plenum Press, 1995), pp. 503–509, 15–24, 193–199, 493–497 (quote from Mansell, "Systems, Rationality, and Equity," p. 493). See also Flood and Jackson, *Critical Systems Thinking,* pp. 1–2.

42. Tony Brauer, "Have You Been Talking to Yourself, René?" Jane A. O. Young, "Politics Versus Learning," Margaret Barrett and Barry Crellin, "Systems Constructs and Cultural Filters: Learning from a Management Development Program in Poland," S. K. Probert, "The Cynicism of Systems Thinking," and Gillian Ragsdell, "The Case for Critical Creativity in TSI: A Necessity, a Practical Possibility, or a Contradiction of Terms," in Keith Ellis et al., eds., *Critical Issues in Systems Theory and Practice* (New York: Plenum Press, 1995), pp. 95–100, 421–426, 427–432, 499–502, 165–171.

43. Richardson, "Introduction," p. 96.

44. Roger Cavallo, ed., *Systems Research Movement: Characteristics, Accomplishments, and Current Developments*, a Report Sponsored by the Society for General Systems Research, Special Issue of *General Systems Bulletin* 9:3 (July 1979): 12, 16, 47, 50.

Epilogue

All systems, it is now proposed
Are either open, or are closed,
The closed have one-to-one relations
But don't result in innovations.
The open are disturbed, adaptive
Or Heisenberg-observer-captive.

—Kenneth Boulding[1]

This project began in response to Robert Lilienfeld's critique of systems theory in his book *The Rise of Systems Theory: An Ideological Analysis* (1978). While there are a wide variety of critiques leveled at systems theory, many from among the systems community itself, that of Lilienfeld, along with others in the same vein, is of central concern in this context. Addressing the range of developments from Ludwig von Bertalanffy's open-system concept to cybernetics, information theory, operations research, game theory, and system dynamics, he suggests that most practitioners of these fields believe that "their work is of more than merely 'technical' value." He goes on to explain what he calls the "missionary" aspect of these new fields: "They appear to be convinced that the discoveries and concepts they have developed are of major philosophical, societal, and even religious significance: They offer new images of humanity and society, of God and the creation of human beings, and of their interrelations." Lilienfeld is specifically addressing himself to the "philosophical and societal claims" made by systems technicians on the basis of their technical work, and adopted as well by administrators, psychiatrists, social workers, and political and social scientists, without "technical" expertise. He argues that the incorporation of systems terminology into administrative and social-science fields is intended to confer scientific legitimacy.[2]

While much of Lilienfeld's critique is accurate and legitimate, especially as it pertains to certain developments within the broad spectrum of systems thought, there are two components of his overall argument that warrant reconsideration. First, he believes that he has established the convergence of the systems disciplines: "The leading representatives of these originally separate fields have themselves recognized and proclaimed that they all represent what is basically one unified approach and way of thinking; divergences, they indicate, are based more on the specific features of narrow problems than on intrinsic differences." He also goes on to point out that the different schools of systems thought and practice all claim a common lineage. However, although the broad variety of developments in the systems field share certain fundamental concepts, the diversity in the respective interpretations of their social and political implications, as well as the considerable variation in practical applications of such concepts, would suggest that the field is far from monolithic, as Lilienfeld maintains.[3]

The second, and more critical, aspect of Lilienfeld's argument that is problematic is his assertion that systems theory offers *nothing more than* an ideology for the emerging technocratic elite. He argues that the image of the world offered by the systems theorists is "scientifically meretricious and unable to stand on its own merits." As a result, its sole significance is in "the implicit claims to power and prestige contained therein. . . . The man who offers an image of society as a closed system . . . and who on the basis of technical work and discovery on such systems demonstrates expertise in these matters is clearly offering to assume benevolent control of society as a closed system, which he will manipulate from a position outside of and superior to that system." Reinforcing this view, which fails to acknowledge Bertalanffy's understanding of the social and psychological implications of his *open system* model or the constructivist epistemology growing out of second-order cybernetics, Lilienfeld associates systems thinking with the scientistic positivism of Auguste Comte.[4]

While this view may be accurate for some developments under the systems umbrella—it can be clearly illustrated in the work of Ralph Gerard, for example—it does not characterize the entire spectrum of systems thought and practice. More importantly, it fails to acknowledge the evolution within the systems field itself. In his analysis of systems theory, Lilienfeld draws heavily on the work of Ida Hoos, who was specifically concerned with the inappropriate transfer of the techniques of operations research and budget-planning programs from narrowly constrained technical problems in the military to issues of public policy and administration during the 1960s. The emergence of "soft" operations research in the 1960s and 1970s reflects efforts *within* the systems field to address identical concerns. In a further testament to the evolutionary potential of systems thought, Hoos has written a more supportive foreword to Hal Linstone's 1994 book *The Challenge of the 21st Century,* now acknowledging his "multi-perspective paradigm" as "one that encourages unbounded thinking and ethical action."[5]

Lilienfeld builds on Hoos's initial critique, extending his analysis to include theoretical developments in the social sciences based on systems concepts, and decrying the "authoritarian potentialities" of systems thinking, which he holds accountable for the increasing bureaucratization and rigidification of society. As a sociologist, he interprets systems theory in light of the polarity in sociological thought between functionalism and conflict theories. Voicing an often-repeated concern, he writes that systems theory "clearly evades the problem of conflicting values in society." In addition, he argues that there is no foundation for individual freedom in "an image of society seen as a system." These arguments—the ideological nature of systems theory, its failure to acknowledge conflicting points of view, and its subordination of the individual to the interests of "society as a whole," or, more accurately, of the technocratic elite—are echoed frequently in recent literature. Postmodern critiques portray systems thought as a totalizing metanarrative, lending itself to oppressive forms of control and manipulation.[6]

Gregg Mitman, for example, writes that the ecosystem concept reinforced a view of nature as a system of components that could be managed, manipulated, and controlled. In his discussion of systems ecology, Peter Taylor argues that the cybernetic theory of feedback mechanisms led to conceptions of society and nature as machines and that "a systems approach to understanding nature moved easily into a systems approach for engineering society," dependent on scientifically informed managerial roles. Such conceptions were seen to support a rigid status quo and to suppress any conflict or resistance, encouraging individual adjustment and adaptation for the sake of the whole. In his discussion of cybernetics, Peter Galison quotes Norbert Wiener: "The scientist is always working to discover the order and organization of the universe, and is thus playing a game against the arch enemy, disorganization." In response, Galison suggests: "Perhaps disorganization, noise, and uncontrollability are not the greatest disasters to befall us. Perhaps our calamities are built more from superorganization, silence, and control."[7]

In *The Postmodern Condition,* Jean-François Lyotard suggests that reducing messages to the function of communicating information "is to adopt an outlook which unduly privileges the system's own interests and point of view." While cybernetic machines do indeed run on information, they have no way of correcting the goals programmed into them, which originate in "prescriptive and evaluative statements." Thus he argues that the cybernetic version of information theory misses the "agonistic aspect of society" and further that what is needed is "a theory of games which accepts agonistics as a founding principle." Echoing Lilienfeld, he writes: "The technocrats declare that they cannot trust what society designates as its needs; they 'know' that society cannot know its own needs since they are not variables independent of the new technologies."[8]

In response to such critical interpretations, I have sought to demonstrate the emphasis on more participatory and inclusive forms of management and social organization in recent work in the general-systems tradition. This emphasis is reflected in the orientations of four former presidents of the SGSR: West Churchman asserts that "there are no experts in the systems approach." George Klir writes: "The fixed idea of powerful systems theorists, who can solve almost all problems for almost all disciplines, should be recognized as a myth and treated accordingly. . . . If [a systems theorist] claims that he is able to solve problems in various disciplines because of his knowledge of general principles, then he is either naive or dishonest." Stafford Beer argues that "scientists can no longer claim to be outside the social milieu within which they operate, invoking objectivity and disinterest." And Peter Checkland suggests that complex social problems are teleological in their concern with ends and means, and, as such, require conceptions of management that transcend the limitations of natural science. For Kurt Lewin, a social psychologist whose work was influential in the general-systems community, the concept of "social engineering" was explicitly intended to address the threat of totalitarianism and to preserve democracy through more effective social-feedback mechanisms and the development of skills in democratic social management among the general populace.[9]

CONFLICT AND SYNTHESIS

Lilienfeld argues that systems theorists tend to see social systems as essentially cooperative without recognizing the potentially coercive nature of such apparent cooperation. Alternatively, pluralistic conceptions of society often portray the world as one of "cosmic conflict among divergent heteronomous values." Ironically, Galison describes the fields of cybernetics, game theory, and operations research as "Manichean sciences" in their complicity with the adversarial models of military research and suggests that postmodernism is more closely linked to this Manichean heritage than is generally recognized, citing Lyotard's appeal to agonistic foundations. Echoing Anatol Rapoport's critiques of game-theoretical models in military discourse, Galison notes that these sciences are premised on the "opacity of the other."[10]

The antinomy between "system" and "antisystem" views seems to reflect two opposing ideologies, which might be described in terms of control and freedom, or alternatively in terms of conflict and reconciliation. Lyotard identifies two basic representational models of society that have dominated social thought during the last century; one views society as a functional whole and the other views it as fundamentally divided. He associates the first orientation with positivism and instrumental rationality, represented specifically in the works of Talcott Parsons. The second approach, which Lyotard describes as "wary of syntheses and reconciliations," he associates with hermeneutics, critical theory, reflexivity, and a consideration of values. Critics of systems theory, especially in relation to its social implications, tend to place it in the first category. Parsons's work, however, is not representative of general-systems views, many of which have incorporated significant elements from the hermeneutic tradition.[11]

Clearly, the language of reconciliation is suspect for good reason, since it has so often been co-opted in the interests of existing power structures, and it is important to acknowledge the "structural violence" inherent in homeostatic models. On the other hand, Kenneth Boulding's concern with the destructive impact of dialectical models that emphasize conflict as the primary motive force in society is legitimate. An ideological commitment to conflict seems to characterize both the right and the left in contemporary politics—the right in terms of competitive individualism and the left in terms of difference and particularity. Both play into the hands of the powers that be, justifying violence and legitimating various forms of exclusion.

A truly inclusive view of nature and society as self-organizing and creative systems implies dispersed agency rather than centralized control, as well as a belief in the ultimate reconcilability of individual aspirations. Richard Rorty defines solidarity as "the ability to think of people wildly different from ourselves as included in the range of 'us'." And while Rorty still insists that the circle can never be expected to embrace all of humankind, David Hollinger argues that "the circle of we . . . embraces diversity; it is not a uniformitarian construct, predicating equality on sameness," and he suggests a "postethnic" perspective that "engage[s] the problem while remaining suspicious of the will to enclose."[12]

Such a belief is reflected in the concept of synergy, a non–zero-sum model of interaction, defined by N. A. Coulter in the *General Systems Bulletin* as "the fusion between different aims and resources to create more between the interacting parties than they had prior to the interaction." The resolution of social contradictions is sought through a "dialectical and dialogical process of balance, justice, and equality, between persons or groups, and between the ideas and resources they represent." He defines synergic power as "the ability to engage others in joint efforts that increase the satisfaction of all." A panel discussion hosted by the Boston chapter of the Society for General Systems Reseaerch (SGSR) in May 1970 addressed the topic "How Can Representative Government Survive?" The report noted the increasing "distrust of officials and 'experts' and loss of shared morality" that has created a "frustrated populace ripe for polarized tribalism and non-negotiable demands." It concludes: "The reversal of these trends will require increased respect for individual differences, reforms to assure fair representation, and inspirational leadership in formulating innovative social goals to unite sub-groups in mutually beneficial efforts."[13]

In "The Coming Era of Systemic Societal Change," Bertram Gross, president of SGSR in 1970, examines "societal change and crisis in post-industrial America" and describes two alternative futures: "an unproclaimed, technocratic totalitarianism in the form of 'friendly fascism,'" and "a humanist reconstruction of power systems, values, and rationality itself." In a statement echoing the harshest critiques of technocracy, he describes the American style of friendly fascism as "a managed society ruled by a faceless and widely dispersed complex of warfare-welfare-industrial-communication-police bureaucracies caught up in developing a new style Atlantic-and-Pacific empire based on a technocratic ideology, a culture of alienation, multiple scapegoats, and competing control networks." Referring to Hannah Arendt's discussion of the banality of evil, Gross suggests that "the banality of bureaucratic evil would be overshadowed by the adaptive creativity of technocratic evil." Further, such a "polished and flexible form of totalitarianism" would not depend upon charismatic leaders, the glorification of the state, or the denial of scientific rationality. In fact, he argues that "*a streamlined and expanded scientific establishment would be an essential part of such a system*."[14]

Rather than seeing this technocratic vision as complicit with the systems view, Donald McNeil, an active member of the International Society for the Systems Sciences (ISSS, formerly SGSR), suggests that it results from "the prevalence of short-sighted, fragmented, and *anti-systemic* worldviews among the very powerful people." According to Gross, humanistic alternatives to "creeping totalitarianism" would require "significant transformations in power structures, values, and rationality," given the irrational nature of current conceptions of scientific rationality. Additional changes would include "painful readjustments in the direction of technological change, in the life-style of scientists, and in the relations among the sciences, arts, and humanities." Most importantly: "The most obvious readjustment would be the massive reordering of priorities to shift science-based technology from instruments of military destruction to concentration on health, nutrition, education, family well-being, transportation, housing and community facilities, etc."[15]

Such a view echoes the humanistic orientation of Bertalanffy's conception of general systems theory and his own critique of the technocratic appropriations of systems concepts, particularly in their failure to incorporate significant and relevant human factors in their analysis. In many ways, his emphasis on "things in context" reflects postmodern concerns. Considering systems in relation to their environment does not imply a commitment to downward causation; on the contrary, it highlights the creativity and adaptability of individuals in relation to each other and to the natural environment. A global perspective does not necessarily entail a totalizing conception of reality.

THE POSSIBILITY OF SELF-TRANSCENDENCE

In her "Cyborg Manifesto," Donna Haraway explores possible conceptions of unity, in opposition to all forms of domination, that would not compromise difference or subordinate the part to a totalitarian image of the whole. She suggests that the cybernetic marriage of human and machine may present unexpected possibilities for transcendence of the dominating context from which they emerged. Appealing to the image of the cyborg, a hybrid of machine and organism, which she describes as "the illegitimate offpring of militarism and patriarchal capitalism, not to mention state socialism," she notes that "illegitimate offspring are often exceedingly unfaithful to their origins." Echoing Bertalanffy's emphasis on the importance of multiple perspectives, she writes:

> From one perspective, a cyborg world is about the final imposition of a grid of control on the planet. . . . From another perspective, a cyborg world might be about lived social and bodily realities in which people are not afraid of their joint kinship with animals and machines, not afraid of permanently partial identities and contradictory standpoints. The political struggle is to see from both perspectives at once because each reveals both dominations and possibilities unimaginable from the other vantage point. Single vision produces worse illusions than double vision or many-headed monsters.[16]

General systems theory should be understood as a mode of inquiry rather than as a rigid model of nature. For the members of the SGSR, it provided an impetus to continually extend the scope of inquiry, and it fostered a more expansive conception of knowledge. There are clearly insights to be gained by examining similar processes at different levels of organization; unifying concepts and principles do not preclude particularity, difference, or uniqueness. While the system concept has often been appropriated in the name of efficiency and control, it is important to acknowledge the possible contributions of a more integrated and holistic way of thinking about, observing, and transforming—creatively and cooperatively—the complex social, ecological, and technological systems that shape our collective reality.

I close with a plea for dialogue—as Boulding would say, a willingness to see the other fellow's point of view—as well as a tempering of polarizing discourse and at least a tentative consideration of the possibility for truly inclusive and cooperative synthesis—the unity in diversity to which Bertalanffy so often appealed. More importantly, real dialogue requires greater attention to the qualitative dimension of relationships, the dynamics of interpersonal interaction that are conditioned by the organizational structures of our culture. The institutions of global capitalism reinforce patterns of competitive individualism, resulting ultimately in the domination of the many by the few, through increasing concentrations of wealth and power among an ever more exclusive minority. Many systems theorists, among others, have argued that this is an inevitable condition of human existence. I am nevertheless optimistic, in the best systems tradition, about the possibilities for a more equitable and truly participatory social order, and Boulding's conception of the integrative function provides a good starting point for such an order, particularly in his emphasis on humility, mutual respect, and love.[17]

In the half century that has elapsed since the beginning of the general-systems venture, the world has not even come close to realizing the ideals of peace, prosperity, and participatory democracy outlined in the Ford Foundation's goals for research in the behavioral sciences; if anything, the possibility of attaining such goals seems more remote than ever. On the other hand, it is during times of greatest challenge that the greatest opportunities present themselves. As Ilya Prigogine demonstrates in his work on far-from-equilibrium systems, the greatest potential for change exists when the system is farthest from equilibrium. At the beginning of the twenty-first century, we citizens of planet Earth find ourselves at such a bifurcation point. Models in the dynamic systems tradition of Jay Forrester and Donella Meadows suggest that we face an inevitable collapse, having overshot the planet's capacity to sustain life. Prigogine's work suggests, however, that in highly unstable situations, there also exists a possibility for the emergence of new, more complex, and r/evolutionary forms of organization. In *Beyond the Limits,* Meadows et al. actually concur with Prigogine on this point, tempering their prophecy of doom with an invitation to envision a more sustainable future. Prevailing against strong initial criticism, Lynn Margulis has finally gained scientific acceptance for her view that symbiosis has played a significant role in evolution. Perhaps it is time that we humans tap into the wisdom embedded in our microbial origins and begin to explore the possibilities for creative self-transcendence in a more collaborative synthesis. The alternatives are not very promising.[18]

NOTES

1. Kenneth Boulding, epigraph in Mihajlo D. Mesarovic, "Foundations for a General Systems Theory," in Mihajlo Mesarovic, ed., *Views on General Systems Theory* (New York: Wiley, 1964), p. 1.

2. Robert Lilienfeld, *The Rise of Systems Theory: An Ideological Analysis* (New York: Wiley, 1978), pp. 1–3.

3. Ibid., p. 2.

4. Ibid., p. 3.

5. Ida Hoos, *Systems Analysis in Public Policy: A Critique* (Berkeley: University of California Press, 1972); "Foreword," in Harold A. Linstone, *The Challenge of the 21st Century: Managing Technology and Ourselves in a Shrinking World* (Albany: State University of New York, 1994), p. xvi. Linstone is an active member of the ISSS (formerly SGSR) and was president in 1993.

6. Lilienfeld, *The Rise of Systems Theory,* p. 4.

7. Gregg Mitman, *The State of Nature: Ecology, Community, and American Social Thought, 1900–1950* (Chicago: University of Chicago Press, 1992), p. 210; Peter Taylor, "Technocratic Optimism, H. T. Odum, and the Partial Transformation of Ecological Metaphor After World War II," *Journal of the History of Biology* 21:2 (1988): 223; Peter Galison, "The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision," *Critical Inquiry* 21 (autumn 1994): 266; Norbert Wiener, *Human Use of Human Beings: Cybernetics and Society* (New York: Avon Books, 1967/1950). See also Emily Martin, *Flexible Bodies: Tracking Immunity in American Culture—From the Days of Polio to the Age of AIDS* (Boston: Beacon Press, 1994), pp. 17–18.

8. Jean-François Lyotard, "From the Postmodern Condition: A Report on Knowledge," in David Ingram and Julia Simon-Ingram, *Critical Theory: The Essential Readings* (New York: Paragon, 1992), pp. 324–325, 331. Lyotard cites social-systems theorist Niklas Luhmann, who argues that the system can only function by reducing its complexity and must induce the adaptation of individual aspirations to its own ends (p. 330); from Niklas Luhmann, *Legitimation durch Verfaren* (Darmstadt: Luchterhand, 1975), p. 35.

9. West Churchman, *The Systems Approach* (New York: Dell Publishing Co., 1968), p. 231; Klir, "Preview: The Polyphonic GST," in George Klir, ed., *Trends in General Systems Theory* (New York: Wiley, 1972), p. 13; Leonard Lewin, "Feedback Problems of Social Diagnosis and Action," in Walter Buckley, ed., *Modern Systems Research for the Behavioral Scientist: A Sourcebook* (Chicago: Aldine, 1968), pp. 441–444.

10. Lilienfeld, *The Rise of Systems Theory,* p. 249; Alvin Gouldner, *For Sociology: Renewal and Critique in Sociology Today* (New York: Basic Books, 1973), p. 342 (quote on cosmic conflict); Galison, "The Ontology of the Enemy," p. 256. Galison argues that for Wiener "opposition is seen to lie at the core of every human contact with the outside world" (p. 263).

11. Lyotard, "From the Postmodern Condition," pp. 320–322.

12. Richard Rorty, *Contingency, Irony, and Solidarity* (Cambridge: Cambridge University Press, 1989), p. 192; cited in David Hollinger "How Wide the Circle of the 'We'? American Intellectuals and the Problem of the Ethnos Since World War II," *American Historical Review* 98:2 (April 1993): 325–328.

13. N. A. Coulter, in *General Systems Bulletin* 8:3 (spring/summer 1978): 10–12; Report from Boston Chapter, in *General Systems Bulletin* 2:3 (Dec. 1970): 30. Coulter refers to Charles Hampden-Turner, *From Poverty to Dignity: A Strategy for Poor Americans* (Garden City, NY: Anchor Press, 1974); and James and Marguerite Craig, *Synergic Power: Beyond Domination and Permissiveness* (Berkeley: Proactive Press, 1974).

14. Bertram Gross, "The Coming Era of Systemic Societal Change," *General Systems Bulletin* 3:1 (May 1971): 11–13 (emphasis in text). See Hannah Arendt, *Eichmann in Jerusalem: A Report on the Banality of Evil* (New York: Viking Press, 1963).

15. Donald McNeil, "Report on Systems Approaches," preliminary draft, March 26, 1996 (unpublished manuscript), p. 8 (my emphasis); Gross, "The Coming Era," p. 13.

16. Donna Haraway, *Simians, Cyborgs, and Women: The Reinvention of Nature* (New York: Routledge, 1991), pp. 149–151, 154 (long passage).

17. I was invited to give the Kenneth Boulding Memorial Lecture at the annual meeting of the ISSS in July 1996. Reflecting one of my primary areas of interest in recent years, my topic was "The Qualitative Dimension of Relationship."

18. See Ilya Prigogine and Isabelle Stengers, *Order Out of Chaos: Man's New Dialogue with Nature* (New York: Bantam, 1984); Donella Meadows, Dennis Meadows, and J. Randers, *Beyond the Limits: Confronting Global Collapse, Envisioning a Sustainable Future* (Post Mills, VT: Chelsea Green, 1992); and Lynn Margulis, *Symbiotic Planet: A New Look at Evolution* (New York: Basic Books, 1998).

Bibliography

ARCHIVAL MATERIALS

KEB/MI: Kenneth Boulding Collection, Bentley Historical Library, University of Michigan at Ann Arbor.

KEB/CU: Kenneth Boulding Collection, University Archives at the University of Colorado at Boulder. (*Note:* These files were in the process of being moved from Boulding's office to the Library Archives, so files are identified by topic in the endnotes.)

"Kenneth Ewart Boulding: 1910–1993," Memorial Collection compiled by Boulding's wife, Elise.

Ralph Waldo Gerard Collection, Special Collections, University of California at Irvine.

James Grier Miller, Personal Files.

Mental Health Research Institute, Historical Records, Ann Arbor, Michigan.

Medical School Records, Bentley Historical Library of the University of Michigan at Ann Arbor.

Center for Advanced Study in the Behavioral Sciences, Archives.

WORKS CITED

Abir Am, Pnina, "The Biotheoretical Gathering, Trans-Disciplinary Authority, and the Incipient Legitimation of Molecular Biology in the 1930s: New Perspectives on the Historical Sociology of Science," *History of Science* 25 (1987): 1–70.

Ackoff, Russell, "Games, Decisions, and Organizations," *General Systems* 4 (1959): 145–150.

Allee, W. C., A. Emerson, T. Park, O. Park, and K. Schmidt, *Principles of Animal Ecology* (Philadelphia: W. B. Saunders, 1949).

Allen, Garland, *Life Science in the Twentieth Century* (New York: Wiley, 1975).
Allen, T.F.H., and Thomas W. Hoekstra, *Toward a Unified Ecology* (New York: Columbia University Press, 1992).
Arendt, Hannah, *Eichmann in Jerusalem: A Report on the Banality of Evil* (New York: Viking Press, 1963).
Aron, Raymond, *Main Currents in Sociological Thought,* Richard Howard and Helen Weaver, trans. (Garden City, NY: Doubleday and Company, 1970/1967).
Ashby, W. Ross, "Adaptiveness and Equilibrium," *Journal of Mental Science* 86 (1940): 478–483.
———, *Design for a Brain* (New York: Wiley, 1952).
———, *An Introduction to Cybernetics* (New York: Wiley, 1956).
Banathy, Bela, "Comprehensive Systems Design in Education," *Educational Technology* (March 1991): 33–35.
———, *Systems Design of Education: A Journey to Create the Future* (Englewood Cliffs, NJ: Educational Technology Publishers, 1991).
———, *A Systems View of Education: Concepts and Principles for Effective Practice* (Englewood Cliffs, NJ: Educational Technology Publishers, 1992).
———, *Designing Social Systems in a Changing World* (New York: Plenum Press, 1996).
Barber, Bernard, ed., *L. J. Henderson on the Social System* (Chicago: University of Chicago Press, 1970).
Bateson, Gregory, *Steps to an Ecology of Mind* (New York: Ballantine Books, 1972).
Beer, Stafford, *Cybernetics and Management* (New York: Wiley, 1959).
———, *Designing Freedom* (Toronto: Canadian Broadcasting Corporation, 1974).
———, *Platform for Change* (New York: Wiley, 1975).
Beier, W., and R. Laue, "On the Mathematical Formulation of Open Systems and Their Steady States," in Gray and Rizzo, eds., *Unity Through Diversity* (1973).
Bell, Daniel, "Twelve Modes of Prediction," in J. Gould, ed., *Penguin Survey of the Social Sciences* (London: Penguin Books, 1965).
Benson, Keith, Jane Maienschein, and Ronald Rainger, eds., *The Expansion of American Biology* (New Brunswick: Rutgers University Press, 1991).
Berlinski, David, *On Systems Analysis: An Essay Concerning the Limitations of Some Mathematical Methods in the Social, Political, and Biological Sciences* (Cambridge, MA: MIT Press, 1976).
Bernard, Claude, *Introduction à l'étude de la médecine expérimentale* (Paris: Ballière, 1865), published in English in 1927, with an introduction by Lawrence Henderson.
Berrien, Kenneth, "Social Systems, Adaptation, and Personality," *General Systems Bulletin* 2:3 (Dec. 1970).
Berry, Wendell, *Life Is a Miracle: An Essay Against Modern Superstition* (Washington, DC: Counterpoint, 2000).
Bertalanffy, Ludwig von, *Fechner und das Problem der Integrationen höherer Ordnun* (Dissertation, 1926).
———, "Zur Theorie der organische Gestalt," *Roux' Archiv* 108 (1926).
———, *Kritische Theorie der Formbildung* (Berlin: Borntraeger, 1928), published in English as *Modern Theories of Development* (London: Oxford University Press, 1933).
———, *Lebenswissenschaft und Bildung* (Erfurt: Kurt Stenger, 1930).
———, "Mechanism and Vitalism in the Light of Critical Biology," *Psyche* 10 (1930): 60–72.
———, *Theoretische Biologie* (Berlin: Gebrüder Borntraeger, 1932).
———, "Der Organismus als physikalisches System betrachtet," *Die Naturwissenschaften* 28 (1940): 521–531.

———, "Open Systems in Physics and Biology," *Nature* 163 (Jan. 29, 1949): 384.
———, "Problems of Organic Growth," *Nature* 163 (Jan. 29, 1949): 156–158.
———, "GST: A New Approach to the Unity of Science," *Human Biology* 23 (1951): 302–312, 336–361.
———, "Theoretical Models in Biology and Psychology," *Journal of Personality* 20 (1951): 24–38.
———, *Problems of Life: An Evaluation of Modern Biological Thought* (New York: Wiley, 1952).
———, "Philosophy of Science in Scientific Education," *Scientific Monthly* 77 (1953): 233–239.
———, "General System Theory," *Main Currents in Modern Thought* 11 (1955): 75–83; reprinted in *General Systems* 1 (1956): 1–10.
———, "Quantitative Laws in Metabolism and Growth," *Quarterly Review of Biology* 32 (1957): 217–231.
———, "General System Theory: A Critical Review," *General Systems* 7 (1962): 1–20.
———, "General System Theory and Psychiatry," in Silvano Arieti, ed., *American Handbook of Psychiatry,* vol. 3 (New York: Basic Books, 1965).
———, "Mind and Body Re-Examined," *Journal of Humanistic Psychology* (1966): 113–137.
———, "The Mind-Body Problem: A New View," in Floyd Matson and Ashley Montagu, eds., *The Human Dialogue: Perspectives on Communication* (New York: Free Press, 1967).
———, *Robots, Men, and Minds: Psychology in the Modern World* (New York: George Braziller, 1967).
———, "The World of Science and the World of Value," in J.F.T. Bugenthal, ed., *Challenges of Humanistic Psychology* (New York: McGraw-Hill, 1967).
———, *General System Theory: Foundations, Development, Applications* (New York: George Braziller, 1968).
———, "General Systems Theory and a New View of the Nature of Man," paper presented at American Psychiatric Association Annual Meeting, 1968 (cited in Ida Hoos, *Systems Analysis in Public Policy*).
———, "Chance or Law," in Koestler and Smythies, eds., *Beyond Reductionism* (1969).
———, "System, Symbol, and the Image of Man," in Iago Galdston, ed., *The Interface Between Psychiatry and Anthropology* (New York: Brunner/Mazel, 1971).
Bertalanffy, Maria von, "Reminiscences," in Gray and Rizzo, eds., *Unity Through Diversity* (1973).
Blitz, David, *Emergent Evolution: Qualitative Novelty and the Levels of Reality* (Boston: Kluwer Academic Publishers, 1992).
Blume, Stuart S., *Toward a Political Sociology of Science* (New York: Free Press, 1974).
Boorstin, Daniel, *The Republic of Technology: Reflections on Our Future Community* (New York: Harper and Row, 1978).
Botkin, Daniel, *Discordant Harmonies* (New York: Oxford University Press, 1990).
Boulding, Kenneth, *Economic Analysis* (New York: Harper, 1941).
———, *There Is a Spirit: The Naylor Sonnets* (New York: Fellowship Press, 1945).
———, *A Reconstruction of Economics* (New York: Wiley, 1950).
———, *The Organizational Revolution: A Study in the Ethics of Economic Organization* (New York: Harper, 1953).
———, "The Desert Frontier: Economics and the Behavioral Sciences," *Diogenes* 15 (fall 1956): 1–14.
———, "General Systems Theory: The Skeleton of Science," *Management Science* 2:3 (April 1956): 197–208.
———, *The Image: The Place of Knowledge in Organisms and Organizations* (Ann Arbor: University of Michigan Press, 1956).

———, "The Taming of Mammon," in Lynn White Jr., ed., *Frontiers of Knowledge* (New York: Harper and Brothers, 1956).
———, "A New Look at Institutionalism," *American Economic Review* 47:2 (May 1957): 1–12.
———, "Organization and Conflict," *Journal of Conflict Resolution* 1:2 (June 1957): 122–134.
———, Review of Lester de Koster, *All Ye That Labor: An Essay on Christianity, Communism, and the Problem of Evil,* in *Reformed Journal* (July–Aug. 1957).
———, *Principles of Economic Policy* (Englewood Cliffs, NJ: Prentice-Hall, 1958).
———, *The Skills of the Economist* (Cleveland: Howard Allen, 1958).
———, "Organizing Growth," *Challenge* 8:3 (Dec. 1959): 108–112.
———, "Political Implications of General Systems Research," *General Systems* 6 (1961): 1–7.
———, *Conflict and Defense: A General Theory* (New York: Harper, 1962).
———, "The Relations of Economic, Political, and Social Systems," *Social and Economic Studies* 11:4 (Dec. 1962): 351–362.
———, "General Systems as a Point of View," in Mihajlo Mesarovic, ed., *Views on General Systems Theory* (New York: Wiley, 1964), pp. 25–38.
———, *The Meaning of the Twentieth Century* (New York: Harper, 1964).
———, "The Economics of the Coming Spaceship Earth," in Henry Jarrett, ed., *Environmental Quality in a Growing Economy, Essays from the Sixth Resources for the Future Forum* (Baltimore: Johns Hopkins University Press, 1966), pp. 3–14.
———, *The Impact of the Social Sciences* (New Brunswick, NJ: Rutgers University Press, 1966).
———, *Beyond Economics: Essays on Society, Religion, and Ethics* (Ann Arbor: University of Michigan Press, 1968).
———, ed., *Peace and the War Industry* (Chicago: Aldine, 1970).
———, *A Primer on Social Dynamics: History as Dialectics and Development* (New York: Free Press, 1970).
———, *Collected Papers*, *Vol. IV: Toward a General Social Science,* Larry Singell, ed. (Boulder, CO: Associated University Press, 1971).
———, *The Economy of Love and Fear: A Preface to Grants Economics* (Belmont, CA: Wadsworth, 1973).
———, "General Systems as an Integrating Force in the Social Sciences," in Gray and Rizzo, eds., *Unity Through Diversity* (1973).
———, Review of Howard Odum, *Energy Basis for Man and Nature,* in *Friend's Journal* 23:9 (1977): 276–277.
———, *Ecodynamics: A New Theory of Societal Evolution* (Beverly Hills, CA: Sage Publications, 1978).
———, *Stable Peace* (Austin: University of Texas Press, 1978).
———, "Universal Physiology," *Contemporary Sociology* 8:6 (Sept. 1979): 687–691.
———, *Beasts, Ballads, and Bouldingisms* (New Brunswick, NJ: Transaction Books, 1980).
———, *Evolutionary Economics* (Beverly Hills, CA: Sage Publications, 1981).
———, "My Life Philosophy," *The American Economist* 29:2 (fall 1985): 5–14.
———, "The Next Thirty Years in General Systems," *General Systems* 29 (1985), reprinted from *General Systems Bulletin* 15:1 (fall 1984).
———, "Systems Research and the Hierarchy of World Systems," *Systems Research* 2:1 (1985): 7–11.
———, *The World as a Total System* (Beverly Hills, CA: Sage Publications, 1985).
———, "Systems Profile: Some Origins," *Systems Research* 4:4 (1987): 283–288.
———, "A Bibliographic Autobiography" *Banca Nazionale del Lavorno Quarterly Review* 171 (Dec. 1989): 3–26.

———, *Three Faces of Power* (Newbury Park, CA: Sage Publications, 1989).
———, "A Ballade of Maturity," *CU-Boulder Summit* 9:1 (spring 1992): 28.
———, *The Structure of a Modern Economy* (New York: New York University Press, 1993).
———, with Michael Kammen and Seymour Martin Lipset, *From Abundance to Scarcity: Implications for the American Tradition* (Columbus: Ohio University Press, 1978).
Bowker, Geof, "How to Be Universal: Some Cybernetic Strategies, 1943–1970," *Social Studies of Science* 23 (1993): 107–127.
Bramwell, Anna, *Ecology in the Twentieth Century: A History* (New Haven: Yale University Press, 1989).
Brand, Stewart, "A Conversation with Gregory Bateson and Margaret Mead," *CoEvolution Quarterly* 10 (1976).
Brauckmann, Sabine, "The Organismic System Theory of Ludwig von Bertalanffy (1926–1937)," *Biologisches Zentralblatt* 115 (1996): 197–205.
Buckley, Walter, ed., *Modern Systems Research for the Behavioral Scientist: A Sourcebook* (Chicago: Aldine, 1968).
———, "A Systems Approach to Epistemology," in Klir, ed., *Trends in General Systems Theory* (1972).
Burrell, G., and G. Morgan, *Sociological Paradigms and Organizational Analysis: Elements of the Sociology of Corporate Life* (London: Heinemann, 1979).
Cannon, Walter, *The Wisdom of the Body* (New York: W. W. Norton, 1932/1963).
Capra, Fritjof, *The Turning Point* (New York: Simon & Schuster, 1982).
———, *The Hidden Connections: Integrating the Biological, Cognitive, and Social Dimensions of Life into a Science of Sustainability* (New York: Doubleday, 2002).
Cavallo, Roger, "Status of Special Task Force Report," *General Systems Bulletin* 9:1 (autumn 1978).
———, ed., *Systems Research Movement: Characteristics, Accomplishments, and Current Developments*, a Report Sponsored by the Society for General Systems Research (Special Issue of *General Systems Bulletin* 9:3 [July 1979]).
Chaffee, S., and John Hochheimer, "The Beginnings of Political Communications Research in the United States: Origins of the 'Limited Effects' Model," in M. Gurevitch and Mark Levy, eds., *Mass Communications Yearbook* 5 (1985).
Checkland, Peter, *Systems Thinking, Systems Practice* (New York: Wiley, 1981).
———, *Soft Systems Methodology in Action* (New York: Wiley, 1990).
Chong, Lisa, and L. Bryan Ray, "Whole-istic Biology," *Science* 295 (March 1, 2002): 1661.
Churchman, C. West, *Challenge to Reason* (New York: McGraw-Hill, 1968).
———, "Operations Research as a Profession," *Management Science* 17 (1970).
———, *The Design of Inquiring Systems* (New York: Basic Books, 1971).
———, and Richard O. Mason, eds., *World Modeling: A Dialogue* (Amsterdam: North-Holland Pub. Co., 1976).
———, *The Systems Approach* (New York: Dell, 1979).
———, *The Systems Approach and Its Enemies* (New York: Basic Books, 1979).
———, with Russell E. Ackoff and Leonard Arnoff, *Introduction to Operations Research* (New York: Wiley, 1957).
Cittadino, Eugene, "The Failed Promise of Human Ecology," in Michael Shortland, ed., *Science and Nature: Essays in the History of the Environmental Sciences* (Oxford: Alden Press, 1993).
Clark, Jere W., "General Ecology of Knowledge in Curriculums of the Future," in Laszlo and Gray, eds., *The Relevance of General Systems Theory* (1972).
Clements, Frederic, *Research Methods in Ecology* (New York: Arno Press, 1977/1905).

———, *Plant Succession* (Washington, DC: Carnegie Institution, 1916).
———, "Nature and Structure of the Climax," *The Journal of Ecology* 24 (1936): 252–284.
Commoner, Barry, "In Defense of Biology," *Science* 133 (1961): 1745–1748.
Cook, T. D., "Postpositivist Critical Multiplism," in R. L. Shotland and M. M. Mark, eds., *Social Science and Social Policy* (Beverly Hills, CA: Sage, 1985).
Coser, Lewis, *Masters of Sociological Thought: Ideas in Historical and Social Context* (San Francisco: Harcourt Brace Jovanovich, 1977/1971).
Craig, James, and Marguerite Craig, *Synergic Power: Beyond Domination and Permissiveness* (Berkeley, CA: Proactive Press, 1974).
Daly, Herman, *Steady-State Economics: The Economics of Biophysical Equilibrium and Moral Growth* (San Francisco: W.H. Freeman, 1977).
Davidson, Mark, *Uncommon Sense: The Life and Thought of Ludwig von Bertalanffy (1902–1972), the Father of General System Theory* (Los Angeles: J. P. Tarcher, 1983).
Dawkins, Richard, *The Selfish Gene* (New York: Oxford University Press, 1976).
Dobbert, Daniel, Review of Miller's *Living Systems, Futurics* 3:3 (1979): 298–300.
Dobzhansky, Theodore, "Are Naturalists Old-Fashioned?" *American Naturalist* 100 (1966): 541–550.
Driesch, Hans, *The History and Theory of Vitalism* (London: Macmillan, 1914).
Dubos, René, "We Are Slaves to Fashion in Research," *Scientific Research* (Jan. 1967): 36–54.
Easton, David, ed., *Varieties of Political Theory* (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1966).
Eddington, Arthur, *The Nature of Physics* (Ann Arbor: University of Michigan Press, 1958).
Ellis, Keith, et al., eds., *Critical Issues in Systems Theory and Practice* (New York: Plenum Press, 1995).
Emerson, Alfred, "The Biological Basis of Social Cooperation," *Illinois Academy of Science Transactions* 39 (1946): 9–18.
Emery, F. E., and E. L. Trist, *Towards a Social Ecology: Contextual Appreciation of the Future in the Present* (New York: Plenum Press, 1972).
Ericson, Richard, ed., *Avoiding Social Catastrophes and Maximizing Social Opportunities: The General Systems Challenge* (Proceedings of the 22nd Annual Meeting, Washington, DC, 1978).
———, "In Remembrance of Margaret," *General Systems Bulletin* 9:2 (Winter 1979).
———, ed., *Improving the Human Condition: Quality and Stability in Social Systems* (Proceedings of 1979 Silver Anniversary Meeting, London).
———, "SGSR at 25: What Agenda for Our Second Quarter Century," Reprint of Presidential Address from 1979 Annual Conference, *General Systems Bulletin* 9:2 (Winter 1979).
Erikson, Erik, *Identity, Youth, and Crisis* (New York: W. W. Norton and Co., 1968).
Espejo, Raul, "What is Systemic Thinking?" *System Dynamics Review* 10:2–3 (summer/fall, 1994): 199–212.
Fleming, Donald, "Introduction," in Jacques Loeb, *The Mechanistic Conception of Life* (Cambridge, MA: Harvard University Press, 1964/1912).
Fletcher, Ronald, *The Making of Sociology: A Study of Sociological Theory* (New York: Charles Scribner's Sons, 1971).
Flood, Robert, and Michael Jackson, eds., *Critical Systems Thinking: Directed Readings* (New York: Wiley, 1991).
Forrester, Jay, *Industrial Dynamics* (Cambridge, MA: MIT Press, 1961).
———, *Urban Dynamics* (Cambridge, MA: MIT Press, 1969).
———, *World Dynamics* (Cambridge, MA: MIT Press, 1971).
Fourier, Joseph, *The Analytical Theory of Heat* (Cambridge: Cambridge University Press, 1878).

Fox, K. A., and D. G. Miles, *Systems Economics: Concepts, Models, and Multidisciplinary Perspectives* (Ames: Iowa State University Press, 1987).

Frankl, Viktor, "Beyond Pluralism and Determinism," in Gray and Rizzo, eds., *Unity Through Diversity* (1973).

Freyhofer, Horst, *The Vitalism of Hans Driesch: The Success and Decline of a Scientific Theory* (Frankfurt: Peter Lang, 1982).

Gaines, Brian, "Progress in General Systems Research," in George Klir, ed., *Applied General Systems Research: Recent Developments and Trends* (1978).

Galison, Peter, "The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision," *Critical Inquiry* 21 (autumn 1994): 228–266.

Gerard, Frosty, "Ralph Waldo Gerard," *Behavioral Science* 20:1 (Jan. 1975): 3–8.

Gerard, Ralph, "Organism, Society, and Science," *Scientific Monthly* 50 (April–June 1940): 340–350, 403–412, 530–535.

———, *Unresting Cells* (New York: Harper, 1940).

———, "A Biological Basis for Ethics," *Philosophy of Science* 9:1 (Jan. 1942): 92–120.

———, "Higher Levels of Integration," *Biological Symposia* 8 (1942): 67–87.

———, "The Organismic View of Society," in *Symposium: Profits and Problems of Homeostatic Models in the Behavioral Sciences* (Chicago Behavioral Science Publications, No. 1, 1953), pp. 12–18.

———, "Levels of Organization," *Main Currents* 12:5 (1956): 104–108.

———, *Concepts of Biology* (Washington, DC: National Academy of Science–National Research Council, Publication 560, 1958).

Gerth, Hans, and C. W. Mills, *From Max Weber: Essays in Sociology* (Oxford: Oxford University Press, 1946).

Ghiselin, Michael, *The Economy of Nature and the Evolution of Sex* (Berkeley: University of California Press, 1974).

Gibbs, J. Willard, *Elementary Principles in Statistical Mechanics, Developed with Especial Reference to the Rational Foundation of Thermodynamics* (New York: C. Scribner's Sons, 1902).

Giddens, Anthony, *Profiles and Critiques in Social Theory* (London: MacMillan Press, 1982).

———, *Social Theory and Modern Sociology* (Cambridge: Polity Press, 1987).

Glance, Natalie S., and Bernardo A. Huberman, "The Dynamics of Social Dilemmas," *Scientific American* (Mar. 1994): 76–81.

Gleason, Herbert, "The Individualistic Concept of the Plant Association," *Bulletin of the Torrey Botanical Club* 53 (1926): 7–26.

Goldsmith, Edward, *The Way: An Ecological World View* (Boston: Shambhala, 1993).

Golley, Frank, *A History of the Ecosystem Concept in Ecology* (New Haven: Yale University Press, 1993).

Gouldner, Alvin, *For Sociology: Renewal and Critique in Sociology Today* (New York: Basic Books, 1973).

———, *The Dialectic of Ideology and Technology: The Origins, Grammar, and Future of Ideology* (New York: Seabury Press, 1976).

Gray, William, "Bertalanffian Principles as a Basis for Psychiatry," in Laszlo and Gray, eds., *The Relevance of General Systems Theory* (1972).

———, "Introduction to Section I: Ludwig von Bertalanffy: Person and Work," in Gray and Rizzo, eds., *Unity Through Diversity* (1973).

———, and Nicholas D. Rizzo, eds., *Unity Through Diversity: A Festschrift for Ludwig von Bertalanffy* (New York: Gordon and Breach, 1973).

———, "Correspondence of Aldous Huxley and Ludwig von Bertalanffy," in Gray and Rizzo, eds., *Unity Through Diversity* (1973).
———, with Leonard Duhl, and Nicholas Rizzo, *General System Theory and Psychiatry* (Boston: Little, Brown, 1969).
Grinker, Roy, *Toward a Unified Theory of Human Behavior* (New York: Basic Books, 1956).
Gross, Bertram, "The New Systems Budgeting," *Administration Review* (March–April 1969).
———, "General Systems Framework for Urban Model-Building," *General Systems Bulletin* 2:1 (March 1970).
Habermas, Jürgen, *Knowledge and Human Interests* (London: Heinemann, 1972).
———, *Communication and the Evolution of Society* (Boston: Beacon Press, 1979).
———, *The Philosophical Discourse of Modernity* (Cambridge, MA: MIT Press, 1992).
Haeckel, Ernst, *Generelle Morphologie der Organismen allgemeine Grundzüge der organischen Formen-Wissenschaft* (Berlin: G. Reimer, 1866).
———, *The Riddle of the Universe* (New York: Harper and Brothers, 1900).
Hagen, Joel, *An Entangled Bank: The Origins of Ecosystem Ecology* (New Brunswick, NJ: Rutgers University Press, 1992).
Halfpenny, Peter, *Positivism and Sociology: Explaining Social Life* (Boston: George Allen and Unwin, 1982).
Hampden-Turner, Charles, *From Poverty to Dignity: A Strategy for Poor Americans* (Garden City, NY: Anchor Press, 1974).
Hammond, Debora, "Perspectives from the Boulding Files," *Systems Research* (Kenneth Boulding Festschrift) 12:4 (1995): 281–290.
———, "Evaluating the Heritage of General Systems Theory," *General Systems Bulletin* 25:1 (spring 1996): 7–21.
———, "Ecology and Ideology in the General Systems Community," *Environment and History* 3:2 (1997).
———, Review of K. Ellis, A. Gregory, B. R. Mears-Young, and G. Ragsdell, eds., *Critical Issues in Systems Theory and Practice* (1995), in *Systems Practice* 11:2 (1997): 218–222.
———, "From Dominion to Co-Creation: A New Vision of Reality Beyond the Boundaries of the Mechanistic Universe," *ReVision: A Journal of Consciousness and Transformation* 21:4 (1999): 4–11.
———, "Exploring the Genealogy of Systems Thinking," *Systems Research and Behavioral Science* 19 (2002).
Haraway, Donna, *Crystals, Fabrics, and Fields: Metaphors of Organicism in Twentieth-Century Developmental Biology* (New Haven: Yale University Press, 1976).
———, *Simians, Cyborgs, and Women: The Reinvention of Nature* (New York: Routledge, 1991).
Harnden, Roger, ed., *How Many Grapes Went into the Wine: Stafford Beer on the Art and Science of Holistic Management* (New York: Wiley, 1994).
Hartman, Nicolai, *Neue Wege der Ontologie* (Stuttgart: W. Kohlhammer, 1949).
Harvey, David, *The Condition of Postmodernity* (Cambridge, MA: Blackwell, 1989).
Hawken, Paul, Amory Lovins, and Hunter Lovins, *Natural Capitalism: Creating the Next Industrial Revolution* (Boston: Little, Brown, 1999).
Hayakawa, S. I., *Language in Action* (New York: Harcourt, Brace, 1941).
Heims, Steve, *Constructing a Social Science for Postwar America: The Cybernetics Group, 1946–1953* (Cambridge, MA: MIT Press, 1991).
Hein, Hilde, "The Endurance of the Mechanism-Vitalism Controversy," *Journal of the History of Biology* 5:1 (spring 1972): 159–188.
Hempel, Carl, "GST and the Unity of Science," *Human Biology* 23 (1951): 313–322.

Henderson, Hazel, *Paradigms in Process* (Indianapolis: Knowledge Systems Inc., 1991).

Henderson, Lawrence, *The Fitness of the Environment: An Inquiry into the Biological Significance of the Properties of Matter* (New York: Macmillan, 1913).

Hesse, Mary, *Models and Analogies in Science* (South Bend, IN: University of Notre Dame Press, 1966).

Hollinger, David, "Academic Culture at Michigan, 1938–1988: The Apotheosis of Pluralism," *Rackham Reports* (1989): 58–101.

———, "How Wide the Circle of the 'We'? American Intellectuals and the Problem of the Ethnos Since World War II," *American Historical Review* 98:2 (April 1993): 317–337.

Holmes, Frederic, *Claude Bernard and Animal Chemistry: The Emergence of a Scientist* (Cambridge, MA: Harvard University Press, 1974).

Hoos, Ida, *Systems Analysis in Public Policy: A Critique* (Berkeley: University of California Press, 1972).

Horkheimer, Max, and Theodor Adorno, *Dialectic of Enlightenment,* John Cumming, trans. (New York: Herder and Herder, 1972).

Hughes, Stuart, *Consciousness and Society: The Reorientation of European Society Thought, 1890–1930* (New York: Alfred A. Knopf, 1961).

Hughes, Thomas, *American Genesis: A Century of Invention and Technological Enthusiasm* (New York: Penguin, 1989).

Hull, David, "Systemic Dynamic Social Theory," *The Sociological Quarterly* 11 (1970): 351–363.

Hume, David, "On the Balance of Trade" (1752), in T. H. Green and T. H. Grose, eds., *Essays Moral, Political, and Literary* (London: Longmans, Green, and Co., 1898).

Hutchinson, G. E., "Circular Causal Systems in Ecology," *Annals of the New York Academy of Science* 50 (1948): 221–246.

Huxley, Julian, *Problems of Relative Growth* (London: Methune and Co., 1932).

Jackson, Michael, "Critical Systems Thinking: Beyond the Fragments," *System Dynamics Review* 10:2–3 (summer–fall 1994): 213–229.

Jay, Martin, *The Dialectical Imagination: A History of the Frankfurt School and the Institute of Social Research, 1923–1950* (Boston: Little, Brown, 1973).

Jenlink, Patrick, "Designing Educational Systems for the Twenty-First Century," *Systems Research and Behavioral Science* 18 (2001): 283–285.

Jessor, Richard, "Behavioral Science: An Emerging Paradigm for Social Inquiry," in Richard Jessor, ed., *Perspectives on Behavioral Science: The Colorado Lectures* (Boulder, CO: Westview Press, 1991), pp. 309–316.

Johnston, William, "Von Bertalanffy's Place in Austrian Thought," in Gray and Rizzo, eds., *Unity Through Diversity* (1973).

Jonas, Hans, "Comments on General System Theory," *Human Biology* 23 (1951): 328–335.

Kamaryt, J., "From Science to Metascience and Philosophy," in Gray and Rizzo, eds., *Unity Through Diversity* (1973).

Kar, Nilamadhab, and Brajaballav Kar, "Social Cognition and the Participatory Planning Process, *Systems Research and Behavioral Science* 19 (2002): 377–382.

Katz, Daniel, and Robert Kahn, *The Social Psychology of Organizations* (New York: Wiley, 1966).

Kay, Lily, *The Molecular Vision of Life: Caltech, the Rockefeller Foundation, and the Rise of the New Biology* (Oxford: Oxford University Press, 1993).

Keller, Evelyn, *Refiguring Life: Metaphors of Twentieth-Century Biology* (New York: Columbia University Press, 1995).

Kerman, Cynthia, *Creative Tension: The Life and Thought of Kenneth Boulding* (Ann Arbor: University of Michigan Press, 1974).

Kevles, Daniel J., *The Physicists: The History of a Scientific Community in Modern America* (New York: Knopf, 1978).

Keynes, John Maynard, *Treatise on Money* (New York: Harcourt, Brace and Co., 1930).

———, *The General Theory of Employment, Interest, and Money* (London: Macmillan, 1936).

Kingsland, Sharon, *Modeling Nature: Episodes in the History of Population Biology* (Chicago: University of Chicago Press, 1985).

———, "Defining Ecology as a Science," in Real and Brown, eds., *Foundations of Ecology* (1991).

Klir, George, ed., *Trends in General Systems Theory* (New York: Wiley, 1972).

———, and Gary Rogers, eds., *Basic and Applied General Systems Research: A Bibliography* (Binghamton: State University of New York, 1977).

———, ed., *Applied General Systems Research: Recent Developments and Trends* (New York: Plenum Press, 1978).

Kloppenberg, James, *Uncertain Victory: Social Democracy and Progressivism in European and American Thought, 1870–1920* (Oxford: Oxford University Press, 1986).

Koestler, Arthur, *The Ghost in the Machine* (New York: Macmillan, 1968).

———, and J. R. Smythies, eds., *Beyond Reductionism: New Perspectives in the Life Sciences* (New York: Macmillan, 1969).

———, "The Tree and the Candle," in Gray and Rizzo, eds., *Unity Through Diversity* (1973).

Köhler, Wolfgang, *Die Physischen Gestalten in Ruhe und im stationären Zustand* (Erlangen: Philosophische Akademie, 1924).

———, "Zum Problem der Regulation," *Roux's Archive* 112 (1927).

Korten, David, *The Post-Corporate World* (San Francisco: Berrett-Koehler, 1999).

Korzybski, Alfred, *Manhood of Humanity* (New York: E. P. Dutton, 1921).

———, *Science and Sanity* (Lakeville, CT: International Non-Aristotelian Library Pub. Co., 1958).

Kramer, Nic J.T.A., and Jacob de Smit, *Systems Thinking: Concepts and Notions* (Leiden, Netherlands: Martinus Nijhoff, 1977).

Kubrin, David, "How Sir Isaac Newton Helped Restore Law 'n' Order to the West," *Liberation* (March 1972): 32–41.

Kuhn, Alfred, "Differences vs. Similarities in Living Systems," *Contemporary Sociology* 8:6 (Sept. 1979).

Kwa, Chunglin, "Radiation Ecology, Systems Ecology, and the Management of the Environment," in Michael Shortland, ed., *Science and Nature: Essays in the History of the Environmental Sciences* (Oxford: Alden Press, 1993).

Lane, David, "With a Little Help from Our Friends," *System Dynamics Review* 10:2–3 (summer–fall 1994): 101–134.

Lasch, Christopher, *The True and Only Heaven: Progress and Its Critics* (New York: Norton, 1991).

Lasker, George, ed., "Preface," *The Relation Between Major World Problems and Systems Learning* (Vol. 1: *The Ecology of Human Knowledge and Global Problems in Systems Perspective;* Vol. 2: *Advances in Holistic Problem Solving and Human Action Systems Research*), SGSR Conference Proceedings (Detroit: SGSR, May 1983).

Laszlo, Ervin, "Introduction: The Origins of General Systems Theory in the Work of Von Bertalanffy," in Laszlo and Gray, eds., *The Relevance of General Systems Theory,* pp. 5–10.

———, and William Gray, eds., *The Relevance of General Systems Theory: Papers Presented to Ludwig von Bertalanffy on His Seventieth Birthday* (New York: George Braziller, 1972).

Leiss, William, *The Domination of Nature* (New York: George Braziller, 1972).

Lenoir, Timothy, *The Strategy of Life: Teleology and Mechanics in Nineteenth-Century German Biology* (Dordrecht, Holland: D. Reidel Publishing Co., 1982).

Lewin, Leonard, ed., *Report from Iron Mountain* (New York: Dial Press, 1967).

Libet, Ben, "R. W. Gerard," *Journal of Neurophysiology* (July 1974): 828–829.

Lilienfeld, Robert, *The Rise of Systems Theory: An Ideological Analysis* (New York: Wiley, 1978).

Lindeman, Raymond, "The Trophic-Dynamic Aspect of Ecology," *Ecology* 23 (1942): 399–418.

Linstone, Harold A., *The Challenge of the 21st Century: Managing Technology and Ourselves in a Shrinking World* (Albany: State University of New York Press, 1994).

Loeb, Jacques, *The Mechanistic Conception of Life* (Cambridge, MA: Harvard University Press, 1964/1912).

———, *The Dynamics of Living Matter* (New York: Columbia University Press, 1906).

Lotka, Alfred, *Elements of Physical Biology* (Baltimore: Williams and Wilkins Company, 1925).

Lovelock, James, *Gaia: A New Look at Life on Earth* (Oxford: Oxford University Press, 1982).

Luce, Duncan, and Howard Raifa, *Games and Decisions* (New York: Wiley, 1957).

Luhmann, Niklas, *Legitimation durch Verfaren* (Darmstadt, Germany: Luchterhand, 1975).

Lyotard, Jean-François, *The Postmodern Condition,* Geoff Bennington and Brian Massumi, trans. (Minneapolis: University of Minnesota Press, 1984).

———, "From the Postmodern Condition: A Report on Knowledge," in David Ingram and Julia Simon-Ingram, *Critical Theory: The Essential Readings* (New York: Paragon, 1992).

Macy, Joanna, *Mutual Causality in Buddhism and General Systems Theory* (Albany: State University of New York Press, 1991).

Margulis, Lynn, *Symbiotic Planet: A New Look at Evolution* (New York: Basic Books, 1998).

Maruyama, Magoroh, "The Second Cybernetics: Deviation-Amplifying Mutual Causal Processes," *American Scientist* 51 (1963): 164–179.

Mathews, Freya, *The Ecological Self* (Maryland: Barnes and Noble, 1991).

Matthews, Fred, *Quest for an American Sociology: Robert E. Park and the Chicago School* (Montreal: McGill-Queen's University Press, 1977).

Maturana, Humberto, and Francisco Varela, *Autopoiesis and Cognition: The Realization of the Living,* Boston Studies in the Philosophy of Science, vol. 42 (Boston: D. Reidel Pub. Co., 1980).

Maxwell, James Clerk, "On Governors," *Proceedings of the Royal Society of London* 16 (1868): 270–283.

Mayr, Otto, *The Origins of Feedback Control* (Cambridge, MA: MIT Press, 1970).

McCarthy, Thomas, "Complexity and Democracy, or the Seducements of Systems Theory," *New German Critique* 35 (spring–summer 1985): 27–53.

McCulloch, Warren, and Walter Pitts, "A Logical Calculus of the Ideas Immanent in Nervous Activity," *The Bulletin of Mathematical Biophysics* 5 (1943): 115–133.

McNeil, Donald, "Report on Systems Approaches: Preliminary Draft," March 29, 1996 (manuscript from author).

Mead, George H., *Mind, Self, and Society,* C. W. Morris, ed. (Chicago: University of Chicago Press, 1967/1934).

Meadows, Donella, Dennis Meadows, J. Randers, and W. W. Behrens, *The Limits to Growth* (New York: University Books, 1972).

Meadows, Donella, Dennis Meadows, and J. Randers, *Beyond the Limits: Confronting Global Collapse, Envisioning a Sustainable Future* (Post Mills, VT: Chelsea Green, 1992).

Meadows, Donella, "Places to Intervene in a System," *Whole Earth* (winter 1997): 78–84.

———, "Dancing with Systems," *Whole Earth* (winter 2001): 58–63.

Menninger, Karl, *The Vital Balance: The Life Process in Mental Health and Illness* (New York: Viking Press, 1963).

Merchant, Carolyn, *The Death of Nature: Women, Ecology, and the Scientific Revolution* (San Francisco: Harper & Row, 1980).

———, *Radical Ecology: The Search for a Livable World* (New York: Routledge, 1992).

———, ed., *Ecology: Key Concepts in Critical Theory* (Atlantic Highlands, NJ: Humanities Press, 1994).

Mesarovic, Mihajlo D., "Foundations for a General Systems Theory," in Mihajlo Mesarovic, ed., *Views on General Systems Theory* (New York: Wiley, 1964).

Miller, George, Eugene Galanter, and Karl Pribram, *Plans and the Structure of Behavior* (New York: Holt, Rinehart, and Winston, 1960).

Miller, James Grier, "Introduction," *Symposium: Profits and Problems of Homeostatic Models in the Behavioral Sciences* (Chicago Behavioral Science Publications, No. 1, Ann Arbor, Michigan: Braun-Brumfield Inc., 1953), pp. 1–11.

———, "Toward a General Theory for the Behavioral Sciences," *The American Psychologist* 10:9 (Sept. 1955): 513–531.

———, "Editorial," *Behavioral Science* 1:1 (Jan. 1956).

———, "Coping with Administrator's Information Overload," *Journal of Medical Education* 39:11 (Nov. 1964): 47–54.

———, "Some Notes on Information Theory," *Journal of Medical Education* 39:11 (Nov. 1964): 182–189.

———, "Living Systems: Basic Concepts," *Behavioral Science* 10 (1965): 193–237.

———, "Living Systems: Structure and Process," *Behavioral Science* 10 (1965): 337–379.

———, "Living Systems: Cross-Level Hypotheses," *Behavioral Science* 10 (1965): 381–411.

———, "EDUCOM: Interuniversity Communications Council, *Science* 54 (Oct. 28, 1966): 483–488.

———, *Living Systems* (New York: McGraw Hill, 1978).

———, "Response to the Reviewers of *Living Systems,*" *Contemporary Sociology* 8:6 (Sept. 1979): 705–715.

———, with G. Brown and T. Keenan, eds.,*Edunet: Report of the Summer Study on Information Networks* (New York: Wiley, 1967).

———, and Jessie L. Miller, "Cybernetics, General Systems Theory, and Living Systems Theory," in Ralph L. Levine and Hiram E. Fitzgerald, eds., *Analysis of Dynamic Psychological Systems,* Vol. 1: *Basic Approaches to General Systems, Dynamic Systems, and Cybernetics* (New York: Plenum Press, 1992).

Mills, C. Wright, *The Power Elite* (Oxford: Oxford University Press, 1959).

Miser, Hugh, and Edward Quade, *Handbook of Systems Analysis* (New York: North-Holland, 1985).

Mitman, Gregg, *The State of Nature: Ecology, Community, and American Social Thought, 1900–1950* (Chicago: University of Chicago Press, 1992).

Möllers, Alfred, *Dauerwaldgedanken* (Berlin: J. Springer, 1939).

Morgan, C. Lloyd, *Emergent Evolution* (London: Williams and Norgate, 1923).

Moritz, Charles, ed., *Current Biography Yearbook* (New York: H. W. Wilson Co., 1965).

Mumford, Lewis, *Technics and Civilization* (New York: Harcourt, Brace & Co., 1934).

Needham, A. E., "The Mathematical Definition of Growth," in Gray and Rizzo, eds., *Unity Through Diversity* (1973).

Needham, Joseph, "Thoughts on the Problem of Biological Organization," *Scientia* 26 (1932).

———, "Review of Bertalanffy, *Theoretische Biologie,*" *Nature* 132 (1933).

Nhat Hanh, Thich, *Being Peace* (Berkeley, CA: Parallax Press, 1987).

Noble, David, *America by Design: Science, Technology, and the Rise of Corporate Capitalism* (New York: Alfred A. Knopf, 1977).

Norgaard, Richard, "A Case for Methodological Pluralism," *Ecological Economics: The Journal of the International Society for Ecological Economics* 1:1 (Feb. 1989): 37–57.

———, with Sharad Lélé, "Sustainability and the Scientist's Burden," *Conservation Biology* (June 1996).

Nyhart, Lynn K., *Biology Takes Form: Animal Morphology and the German Universities, 1800–1900* (Chicago: University of Chicago Press, 1995).

Odum, Howard, *Energy Basis for Man and Nature* (New York: McGraw-Hill, 1976).

Packard, Vance, *Hidden Persuaders* (New York: D. McKay Co., 1957).

Parascondola, John, "Organismic and Holistic Concepts in the Thought of L. J. Henderson," *Journal for the History of Biology* 4:1 (spring 1971): 63–113.

Park, Robert, *Human Communities: The City and Human Ecology; The Collected Papers of Robert Ezra Park,* vol. 2, E. C. Hughes et al., eds. (Glencoe, IL: Free Press, 1952).

———, *On Social Control and Collective Behavior,* Ralph H. Turner, ed. (Chicago: University of Chicago Press, 1967).

Parsons, Talcott, *The Structure of Social Action* (New York: McGraw-Hill, 1937).

———, *The Social System* (New York: Free Press, 1951).

———, *The System of Modern Societies* (Englewood Cliffs, NJ: Prentice-Hall Inc., 1971).

———, "Concrete Systems and 'Abstracted Systems,'" *Contemporary Sociology* 8:6 (Sept. 1979): 696–705.

Pask, Gordon, *Conversation, Cognition, and Learning* (Amsterdam: Elsevier, 1975).

Pauly, Philip, *Controlling Life: Jacques Loeb and the Engineering Ideal in Biology* (Berkeley: University of California Press, 1987).

Pepper, Steven, *World Hypotheses: A Study in Evidence* (Berkeley: University of California Press, 1942).

Peterson, Richard, *The Industrial Order and Social Policy* (Englewood Cliffs, NJ: Prentice Hall Inc., 1973).

Phillips, D. C., *Holistic Thought in Social Science* (Stanford, CA: Stanford University Press, 1976).

Piaget, Jean, *Structuralism,* C. Mascher, trans. (New York: Harper & Row, 1971).

Polak, Fred, *The Image of the Future,* Elise Boulding, trans. (New York: Elsevier, 1973).

Poundstone, William, *Prisoner's Dilemma* (New York: Doubleday, 1992).

Prigogine, Ilya, *Étude thermodynamique des phénomènes irréversibles* (Paris: Dunot, 1947).

———, and J. M. Wiame, "Biologie et thermodynamique des phénomènes irréversibles," *Experientia* 2 (1946).

———, and Isabelle Stengers, *Order Out of Chaos: Man's New Dialogue with Nature* (New York: Bantam, 1984).

Raban, Jonathan, *Soft City* (London: Hamilton, 1974).

Rapoport, Anatol, "Newtonian Physics and Aviation Cadets," *ETC: A Review of General Semantics* 1:3 (1944): 154–163.

———, "Mathematical Theory of Motivation of Interactions of Two Individuals," *Bulletin of Mathematical Biophysics* 9:1 (1947): 17–27.

———, "Cycle Distribution in Random Nets," *Bulletin of Mathematical Biophysics* 10:3 (1948): 145–157.

———, *Science and the Goals of Man: A Study in Semantic Orientation* (New York: Harper, 1950).

———, *Operational Philosophy* (New York: Harper, 1953).

———, "Lewis Richardson's Mathematical Theory of War," *The Journal of Conflict Resolution* 1 (1957): 249–299.

———, *Fights, Games, and Debates* (Ann Arbor: University of Michigan Press, 1960).
———, “The Use and Misuse of Game Theory,” *Scientific American* (Dec. 1962): 108–114.
———, *Strategy and Conscience* (New York: Harper, 1964).
———, “The Promise and Pitfalls of Information Theory,” in Buckley, ed., *Modern Systems Research for the Behavioral Scientist* (1968), pp. 137–142.
———, *The Big Two: Soviet-American Perceptions of Foreign Policy* (New York: Bobbs-Merrill, 1971).
———, “Bertalanffy’s Contributions to Biology,” *General Systems* 17 (1972).
———, “In Memoriam: Ludwig von Bertalanffy,” *General Systems* 17 (1972).
———, “The Uses of Mathematical Isomorphism in GST,” in Klir, ed., *Trends in General Systems Theory* (1972).
———, *Conflict in Man-Made Environment* (London: Penguin Books, 1974).
———, *Semantics* (New York: Thomas Crowell, 1975).
———, *The 2 x 2 Game* (Ann Arbor: University of Michigan Press, 1976).
———, “Application of Game Theoretical Concepts in Biology,” *Bulletin of Mathematical Biology* 47:2 (1985): 161–192.
———, *General System Theory: Essential Concepts and Applications* (Cambridge, MA: Abacus Press, 1986).
———, *The Origins of Violence: Approaches to the Study of Conflict* (New York: Paragon House, 1989).
———, *Gewissheiten und Zweifel* (Darmstadt: Verlag Darmstädter Blätter, 1994); to be published in English as *Certainties and Doubts*.
———, “The Systemic Approach in Psychology,” *Psikhologicheskyi Zhurval* 15:3 (1994).
———, and A. Shimbel, “Statistical Approach to the Theory of the Central Nervous System,” *Bulletin of Mathematical Biophysics* 10:1 (1948): 41–55.
———, and Albert Chammah, *The Prisoner’s Dilemma: A Study of Conflict and Cooperation* (Ann Arbor: University of Michigan Press, 1965).
Rashevsky, Nicholas, “A Problem of Mathematical Biophysics of Interaction of Two or More Individuals Which May Be of Interest in Mathematical Sociology,” *Bulletin of Mathematical Biophysics* (cited in Rapoport, *Gewissheiten und Zweifel,* 1994).
———, *Mathematical Biology of Social Behavior* (Chicago: University of Chicago Press, 1951).
Raushenbush, Winifred, *Robert E. Park: Biography of a Sociologist* (Durham, NC: Duke University Press, 1979).
Real, L. A., and J. H. Brown, eds., *Foundations of Ecology: Classic Papers with Commentaries* (Chicago: University of Chicago Press, 1991).
Reckmeyer, William, “The Current Nature and Scope of General Systems Education,” n.d. (manuscript from author).
Richardson, George, “Introduction: System Thinkers, Systems Thinking,” *System Dynamics Review: The Journal of the System Dynamics Society* 10:2–3 (summer–fall 1994): 95–99.
———, *Feedback Thought in Social Science and Systems Theory* (Philadelphia: University of Pennsylvania Press, 1991, reprinted by Pegasus Communications, Waltham, MA, 1999).
Richardson, Lewis, *Arms and Insecurity: A Mathematical Study of the Causes and Origins of War* (Pittsburgh: Boxwood Press, 1960).
———, *Statistics of Deadly Quarrels* (Pittsburgh: Boxwood Press, 1960).
Riesman, David, *The Lonely Crowd: A Study of the Changing American Character* (New Haven: Yale University Press, 1950).
———, “Leisure and Work in Post-Industrial Society,” in E. Larrabee and R. Mayershon, eds., *Mass Leisure* (Glencoe, IL: Free Press, 1958).

Riskin, Jessica, “From Electricity to Economy: Enlightenment Debates in Natural and Political Philosophy” (unpublished paper, 1994).
Ritterbush, Philip, *The Art of Organic Form* (Washington, DC: Smithsonian Institute Press, 1968).
Rizzo, Nicholas, “The Significance of Von Bertalanffy for Psychology,” in Laszlo and Gray, eds., *The Relevance of General Systems Theory* (1972).
———, “Introduction to Section IV: GST in the Behavioral Sciences: Toward a New Image of Man,” in Gray and Rizzo, eds., *Unity Through Diversity* (1973).
Rorty, Richard, *Contingency, Irony, and Solidarity* (Cambridge: Cambridge University Press, 1989).
Rosen, Robert, “Some Systems Theoretical Problems in Biology,” in Laszlo and Gray, eds., *The Relevance of General Systems Theory* (1972).
———, “A Survey of Dynamical Descriptions of System Activity,” in Gray and Rizzo, eds., *Unity Through Diversity* (1973).
———, “Autobiographical Reminiscences,” *International Journal of General Systems* 21:1 (Aug. 1992).
Rosenbleuth, Arturo, Norbert Wiener, and Julian Bigelow, “Behavior, Purpose, and Teleology,” *Philosophy of Science* 10 (1943): 18–24.
Rosenhead, J., “Introduction: Old and New Paradigms of Analysis,” in J. Rosenhead, ed., *Rational Analysis for a Problematic World* (New York: Wiley, 1989).
Ross, D. M., “Ludwig von Bertalanffy: Leading Theoretical Biologist of the Twentieth Century,” in Gray and Rizzo, eds., *Unity Through Diversity* (1973).
Ross, Dorothy, *The Origins of American Social Science* (Cambridge: Cambridge University Press, 1991).
Rubin, Milton, “Report on the 1969 SGSR Annual Meeting,” *General Systems Bulletin* 2:1 (March 1970).
———, “The General Systems Program: Where Are We Going?” in Milton Rubin, ed., *Man in Systems,* Proceedings of 1968 Annual Conference in Dallas (New York: Gordon and Breach, 1971).
Russell, E. S., *The Interpretation of Development and Heredity* (Oxford: Clarendon Press, 1930).
———, “Review of Bertalanffy, *Theoretische Biologie,*” *Science Progress* (1933).
Sapp, Jan, “Symbiosis and Disciplinary Demarcations: The Boundaries of the Organism,” *Symbiosis* 17 (1994): 91–115.
———, “Cell Evolution and Organelle Origins: Metascience to Science,” *Archiv für Protisten Kunde* 145 (1995): 263–275.
Savory, Allan, *Holistic Management: A New Framework for Decision Making* (Washington, DC: Island Press, 1999).
Schanck, R. L., *The Permanent Revolution in Science* (New York: Philosophical Library, 1954).
Schellenberg, James, *Masters of Social Psychology: Freud, Mead, Lewin, and Skinner* (New York: Oxford University Press, 1978).
Schon, Donald, *Beyond the Stable State* (London: Shaw & Temple, 1971).
Schorske, Carl, *Fin de Siècle Vienna: Politics and Culture* (New York: Vintage, 1981/1961).
Schrödinger, Erwin, *What Is Life? The Physical Aspect of the Living Cell and Mind and Matter* (Cambridge: Cambridge University Press, 1967/1944).
Scott, W. Richard, *Organizations: Rational, Natural, and Open Systems* (Englewood Cliffs, NJ: Prentice-Hall, 1981).
Senge, Peter, *The Fifth Discipline: The Art and Practice of the Learning Organization* (New York: Doubleday, 1990).
Shannon, Claude, and Warren Weaver, *The Mathematical Theory of Communication* (Urbana: University of Illinois Press, 1949).

Sherrington, Charles, *The Integrative Action of the Nervous System* (New York, C. Scribner's Sons, 1906).

Simon, Herbert, *Models of Man, Social and Rational: Mathematical Essays on Rational Human Behavior in Society Setting* (New York: Wiley, 1957).

Simpson, Christopher, *Science of Coercion: Communication Research and Psychological Warfare, 1945–1960* (Oxford: Oxford University Press, 1994).

Smiddy, Harold, and Lionel Naum, "Evolution of a 'Science of Managing' in America," *Management Science* 1:1 (Oct. 1954): 1–31.

Smith, Adam, *An Inquiry into the Nature and Causes of the Wealth of Nations* (London: W. Strahan and T. Cadell, 1776).

Smith, Maynard, *Evolution and the Theory of Games* (Cambridge: Cambridge University Press, 1982).

Smuts, Jan Christiaan, *Holism and Evolution* (New York: MacMillan, 1926).

Snow, C. P., *The Two Cultures and the Scientific Revolution* (New York: Cambridge University Press, 1959).

Sorokin, Pitirim, *Sociological Theories of Today* (New York: Arno Press, 1979).

Sperry, Roger, "A Modified Concept of Consciousness," *Psychological Review* 76 (1969).

Szilard, Leo, "Über die Entropieverminderung in einem thermodynamischen System bei Eingriffen intelligenter Wesen," *Zeitschrift fur Physik* 53 (1929).

Tansley, Arthur, "The Use and Abuse of Vegetational Concepts and Terms," *Ecology* 16 (1935): 284–306.

Taylor, Peter, "Technocratic Optimism, H. T. Odum, and the Partial Transformation of Ecological Metaphor After World War II," *Journal of the History of Biology* 21:2 (summer 1988): 213–244.

———, "Ecosystems as Circuits: Diagrams and the Limits of Physical Analogies," *Biology and Philosophy* 6:2 (April 1991): 275–294.

Taylor, Richard, "Comments on a Mechanistic Conception of Purposefulness," in Buckley, ed., *Modern Systems Research for the Behavioral Scientist* (1968), pp. 226–231.

Thackray, Arnold, "CASBS: Notes Toward a History," *CASBS Annual Report* (1984): 59–71.

Thayer, Lee, "Communication Systems," in Gray and Rizzo, eds., *Unity Through Diversity* (1973).

Thomas, William L., Jr., *Man's Role in Changing the Face of the Earth* (Chicago: University of Chicago Press, 1956).

Thompson, D'Arcy, *On Growth and Form* (Cambridge: Cambridge University Press, 1917).

Thompson, James D., and Donald R. Van Houten, *The Behavioral Sciences: An Interpretation* (Reading, MA: Addison-Wesley, 1970).

Thompson, Michael, and Michael Warburton, "Decision Making Under Contradictory Certainties: How to Save the Himilayas When You Can't Find Out What's Wrong with Them," *Journal of Applied Systems Analysis* 12 (1985): 3–34.

Thoreau, Henry David, *Walden* (1854); passage on dedication page from Robert Bly, *News of the Universe: Poems of Twofold Consciousness* (San Francisco: Sierra Club Books, 1980), p. 72.

Toffler, Alvin, *Future Shock* (New York: Random House, 1970).

Tugwell, Rexford, ed., *The Trend of Economics* (New York: A. A. Knopf, 1924).

Tyler, Ralph, "Institutional Organization of the Behavioral Sciences," in Bernard Berelson, ed., *The Behavioral Sciences Today* (New York: Basic Books, 1963).

Ulrich, Werner, *Critical Heuristics of Social Planning: A New Approach to Practical Philosophy* (Bern, Switzerland: Haupt, 1983).

Vickers, Geoffrey, *The Art of Judgment* (London: Chapman and Hall, 1965).

Virchow, Rudolf, "Atome und Individuen," *Vier Reden über Leben und Kranksein* (Berlin: Georg Reimer, 1862).

Virtanen, Reino, *Claude Bernard and His Place in the History of Ideas* (Lincoln: University of Nebraska Press, 1960).

Volterra, Vito, *Leçons sur la théorie mathématique de la lutte pour la vie* (Paris: Villars, 1931).

Von Foerster, Heinz, ed., *Cybernetics: Circular Causal and Feedback Mechanisms in Biological and Social Systems* (New York: Macy Foundation, 1952).

———, ed., *Cybernetics of Cybernetics: The Control of Control and the Communication of Communication* (Urbana: Biological Computer Laboratory, University of Illinois, 1974).

Von Neumann, John, and Oskar Morgenstern, *Theory of Games and Economic Behavior* (Princeton: Princeton University Press, 1944).

Wagner, H. R., "Types of Sociological Theory: Toward a System of Classification," *American Sociological Review* (Oct. 1963).

Warfield, John, "Principles of Interactive Management," *Proceedings of the International Conference on Cybernetics and Society* (New York: IEEE, 1984).

———, *Understanding Complexity: Thought and Behavior* (Palm Harbor, FL: Ajar Publishing, 2002).

Weibe, Robert, *The Search for Order, 1877–1920* (New York: Hill and Wang, 1966).

Wheatley, Margaret, *Leadership and the New Science* (San Francisco: Berrett-Koehler, 1992).

White, Jay Dixon, ed., *General Systems Theorizing: An Assessment and Prospects for the Future,* SGSR Conference Proceedings (Boston: SGSR, 1976).

———, *The General Systems Paradigm: Science of Change and Change of Science,* SGSR Conference Proceedings (Denver: SGSR, 1977).

White, Leonard D., *The State of the Social Sciences* (Chicago: University of Chicago Press, 1956).

Whitehead, Alfred North, *Science and the Modern World* (New York: Macmillan, 1925).

Wiener, Norbert, *Cybernetics: Or Control and Communication in the Animal and the Machine* (Cambridge, MA: MIT Press, 1948).

———, *Human Use of Human Beings: Cybernetics and Society* (New York: Avon Books, 1967/1950).

Williams, J. D., *The Compleat Strategyst* (New York: McGraw-Hill, 1966).

Woodger, J. H., "The 'Concept of Organism' and the Relation Between Embryology and Genetics," *Quarterly Review of Biology* 5/6 (1930–1931).

———, *The Axiomatic Method in Biology* (Cambridge: Cambridge University Press, 1937).

Worster, Donald, "Grass to Dust: Ecology and the Great Plains in the 1930s," *Environmental Review* 3 (1977): 2–11.

———, *Nature's Economy: The Roots of Ecology* (San Francisco: Sierra Club Books, 1977).

———, "The Ecology of Order and Chaos," *Environmental History Review* 14:1–2 (spring–summer 1990): 1–18.

Zerbst, E. "The Impact of Von Bertalanffy on Physiology," in Laszlo and Gray, eds., *The Relevance of General Systems Theory* (1972).

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