6 Five Areas of Research

Now that we have a working knowledge of the key environmental forces impacting SACS, we turn our attention to the inside of this community. As we noted repeatedly, and as shown in Map 4, there are five major areas of research in SACS: complex social network analysis (CSNA), computational sociology, the British-based School of Complexity (BBC), the Luhmann School of Complexity (LSC) and sociocybernetics.

Our goal in this chapter is to review these five areas. We organize our review around the *web of social practices profile* for each area.

As we discussed in Chaps. 2 and 3, the web of social practices profile for SACS is comprised of six sections: (1) *Complexity science lineage*, which explores how the area of research has been historically influenced by systems science, cybernetics and, in some cases, artificial intelligence; (2) *Sociological lineage,* which explores how the area of research has been historically influenced by the various traditions in sociology, particularly systems thinking; (3) *Complexity science method*, which explores how agent-based modeling writ large is used in the particular area of research; (4) *Sociological method*, which explores how the area of research makes use of the various methodologies and techniques currently available in sociology; (5) *Complexity science topics*, which explores how and to what extent the area of research is involved in one or more of the five major themes that dominant complexity science today and (6) *Sociological topics*, which explores the substantive topics, issues and concerns in sociology that are important to the particular area of research.

It is important to note, however, that while we address all six sections for each area of research, we do not address these sections in the same order or give all six sections equal billing in our review of each area of research. For example, while our review of complex social network analysis (CSNA) is broken down according to all six sections, it does not follow the order shown in the previous paragraph. Another example is our review of the British-based School of Complexity (BBC), which collapses complexity science topics and sociological topics into one section.

Finally, if an area of research is comprised of one or more sub-clusters of research, we end by reviewing those areas. For example, CSNA is comprised of two sub-clusters of research: global network society and the new science of networks.

6.0 Complex Social Network Analysis

The first and most popularized area of research in SACS is complex social network analysis (CSNA). It has the following *web of social practices* profile.

Complexity Science Lineage: The term "network" is probably not the first thing that comes to mind when thinking about systems science. Nevertheless, CSNA has a rather fascinating, although not initially obvious, connection with the twin traditions of systems science and cybernetics. As Capra (1996) and others note (Hammond 2003; Jantsch 1980), the term has played an important role in the development of these two traditions, as well as the advancement of complexity science. For example, in the cybernetic study of communications systems, the concept of networks is very important: information networks, telecommunications networks, computer networks, wiring diagrams, graphs, the internet, the World Wide Web, etc. It is also relevant to chemistry including the study of catalytic cycles, dissipative structures, bifurcation points and phase-structures, as well as systems biology and the study of cellular structures and ecosystems. Going even further along the disciplinary food-chain, the term *network* has been crucial to the development of artificial intelligence, starting with McCulloch and Pitts and their first mathematical model of an artificial neural network. The concept of network also is linked to the advances in distributed artificial intelligence and connectionism, and then (finally) to the more recent advances in neural nets, genetic algorithms and agent-based modeling (Garson 1998).

Given this web of influences, the ground-breaking work of CSNA did not just "suddenly emerge." It came from a rather rigorous and important intellectual lineage. The best example is Watts and Strogatz's famous 1998 article in *Nature*, title *Collective Dynamics of Small-World Networks* (1998). If one examines the 27 references cited in this paper, they read like an abridged history of the term *network* in systems and complexity science. There are, for example, references to chemistry, systems biology, artificial neural networks and ecology as well as systems science, cellular automata and dynamical systems theory. More specifically, there are references to Robert Axelrod and Stuart Kauffman: two of the most important pioneers in complexity science. Furthermore, Steven Strogatz, is a widely recognized figure in dynamical systems theory, specifically the study of chaos (Strogatz 1994).

Complexity Science Method: CSNA's connection to the methods of complexity science is more obvious. For example, as the citations in Watts and Strogatz's article demonstrate, CSNA makes extensive use of a variety of areas in complexity science, including graph theory, evolutionary game theory, artificial neural networks and discrete mathematics. It also makes use of agent-based modeling, including Boolean networks and, more specifically, cellular automata. For a thorough and updated review of the major developments in CSNA, go to (1) Albert-László Barabási's website (www.barabasilab.com/) and also (2) the *International Network for Social Network Analysis* (www.insna.org/)

Sociological Method: In terms of sociological method, the most important contribution comes from social network analysis (Scott 2000, 2002; Scott, Carrington and Wasserman 2005). For example, Watts and Strogatz's 1998 publication in *Nature* cites Kochen's (1989) edited volume on the small-world problem and Wasserman and Faust's *Social Network Analysis: Methods and Applications* (1994). Newman and Barabási likewise cite regularly the social network literature, as do many scholars involved in the new science of networks. Wallerstein, Castells and Urry also make regular use of social network analysis, albeit to study world systems, globalization, and the new global network society.

Complexity Science Topics: The most important topic in CSNA is the complex system. As we noted earlier, complexity scientists use the term network and system interchangeably. This is an important point to remember because, when reading the CSNA literature, particularly the new science of networks, one does not see the term system extensively used, although that is what they are often discussing (Capra 1996; Cilliers 1998; Hammond 2003). Capra makes this point, for example, in the study of living systems. He states, "The view of living systems as networks provides a novel perspective on the so-called hierarchies of nature. Since living systems at all levels are networks, we must visualize the web of life as living systems (networks) interacting in network fashion with other systems (networks)" (p. 35).

The etymological relationship between system and network has continued into CSNA. For example, while the LSC and sociocybernetics talk about social systems, scholars in CSNA talk about networks, extending from the *new science of networks* research of Barry Wellman and Phillip Bonacich to the *complex global network* research of Manuel Castells and John Urry. Nonetheless, everyone is talking about the same thing. The main difference is that the scholars in CSNA see the concept of network as the most valuable way to study social systems. In fact, one can define CSNA as the study of the structure and dynamics of large, complex systems, particularly human social systems, through the theories and methods of social network analysis.

Sociological Topics: In terms of sociological topics, the focus of CSNA is rather extensive, ranging from the study of internet communities, mobile societies and global social networks to epidemiology, health behaviors and the spread of disease to professional ties, interlocking directorates and poverty traps. In fact, the work of CSNA is so broad that it cannot be discussed intelligently in anything less than a book. For a good introduction to this far-reaching literature see Barabási (2003), Buchanan (2002), Freeman (2004), Scott (2000, 2002), Scott, Carrington and Wasserman (2005) and Watts (2003).

Here are, nevertheless, two examples. The first comes from the sociology of occupations and the sociology of organizations literature (Capra 2002). Here the focus is on the network structure and dynamics of formal organizations, businesses, and their various economic associations (Salganik, Dodds, and Watts 2006). Interestingly enough—and we do not have time to address this issue fully—scholars in CSNA have not developed the study of formal organizations to the extent one might imagine (Freeman 2004). In fact, if one wants to learn more about organizations as complex social networks, one has to go to another area within complexity science altogether: the computational economics, management sciences and business literature (Hammond 2003). Like CSNA, all three of these areas have a rich connection to systems science, cybernetics and the development of complexity science method, including associations with (1) the *Sloan School of Management* at the *Massachusetts Institute of Technology*; (2) the systems dynamics work of Jay Forrester (sysdyn.clexchange.org/ people/jay-forrester.html) and (3) the soft systems methodology of Peter Checkland (www.lums.lancs.ac.uk/profiles/peter-checkland/). As a side note, Checkland is a professor at *Lancaster University*, UK, where John Urry and many other leading scholars in the British-based school of complexity are employed or affiliated.

The second example comes from the globalization literature, which is housed, in part, in the British-based school of complexity. This literature draws extensively on the "global network theory" of Manuel Castells (2000a, 200b), the world systems theory of Wallerstein (2005), and the global complexity and mobile sociology literature of John Urry (2003). We will discuss this second example in greater detail below.

Sociological Lineage: Within sociology, CSNA draws upon a variety of micro-interactionist traditions, including exchange theory, game theory, rational-choice theory, and symbolic interactionism. All of them, in one way or another, are linked to the theoretical and conceptual work of social network analysis. As Freeman explains (2004), although social network analysis tends to be treated primarily as a method (Scott 2000), it is also a theory with significant connections to cultural anthropology (exchange theory), political economy (game theory, rational-choice theory) and agency-oriented theories such as symbolic interactionism. One can even go further and trace many of these micro-level theories to Emile Durkheim—who is on our short list of founding "sociological systems thinkers."

6.0.1 The Sub-Clusters of CSNA

While the above profile provides a general introduction to CSNA, its scholars can be divided into two major subclusters of study, each with its own unique take on the traditions, methods and topics of sociology and complexity science.

6.0.1.1 The New Science of Networks

The first subcluster of research in CSNA is the *new science of networks*. As shown in Maps 4 and 6, in addition to Duncan Watts, other key scholars in this field include Albert-László Barabási, Mark Newman, Philip Bonacich and Barry Wellman.

Albert-László Barabási is *Emil T. Hofman Professor of Physics* and Director of the *Center for Complex Networks* at the University of Notre Dame, USA. Like Watts, Barabási's focuses on the structure of complex networks. Barabási's focus, however, has taken him in an entirely different direction. Shortly after Watts's ground-breaking work on the small-world phenomena, Barabási and his team made several discoveries to do with the scale-free nature of large networks (www.nd.edu/%7Ealb/html/people.html). Put simply, Barabási found that the network connections in complex networks follow a power law, with the mostly densely connected nodes being the least frequent and the least connected nodes occurring the most, and he found this to be true at multiple levels. Like Watts, this insight gave researchers some confidence that complex networks, although overwhelming in their structure, are not entirely random. Instead, they adhere to one of the dominant principles of the universe: order exists amidst chaos. Barabási and his research team have recently turned their attention to the structure of economic and human-disease networks. For a detailed overview of their projects, along with some tremendous graphics, go to the *Center for Complex Network Research* (http://www.nd.edu/~networks/) or their *Product Space and Wealth of Nations* website (www.nd.edu/%7Enetworks/productspace/index.htm).

Mark Newman is *Professor of Physics and Complex Systems* at the University of Michigan, USA. He is also a faculty member in the *Center for the Study of Complex Systems* at University of Michigan—the brainchild of John Holland and home to Robert Axelrod—and he is an external faculty member of the Santa Fe Institute. As stated on his website, Newman is interested in three key aspects of networks: affiliation, collaboration and network flows (www.lsa.umich.edu/physics/peopleprofile/0,2708,,00.html?ID=802).

Affiliation has to do with "who knows who in a community, how contact networks form, and how structure affects the diffusion of information over networks…" (Ibid). Collaboration has to do with information exchange, as in the "networks of scientists and business-people…" (Ibid). Flows have to do with such phenomena as the spread of disease and infection through a network, as well as network epidemics.

Philip Bonacich is *Professor of Sociology* at the University of California, Los Angeles (UCLA) and Editor of *Journal of Mathematical Sociology*. He is an important figure in the history of social network analysis, and is known for such methodological innovations as his modification of the degree centrality approach, a measure of how connected and influential people are in a social network (Scott 2000; Scott, Carrington and Wasserman 2005). In fact, Bonacich's methodological innovations connect him to the new science of networks, where he is applying evolutionary game theory, cellular automata and simulation to the study of social networks. His reviews of key publications in the new science of networks have also helped to bridge the divide between sociologists and complexity scientists (2004a, 2004b). So have his involvements in the development of the *UCLA Center for Human Complex Systems*, one of the few undergraduate programs in the United States devoted to the study of complex networks (hcs.ucla.edu/home.htm).

Barry Wellman is, in the language of network analysis, an authority. Hubs, like Duncan Watts, are the most densely connected nodes in a network; authorities, like Wellman, facilitate linkages. One small example is the numerous academic titles Wellman holds. Here are just a few: (1) *S.D.* Clark Professor of Sociology, *University of Toronto*; (2) Research Associate, *Centre for Urban and Community Studies*, University of Toronto; (3) *NetLab* Director; and (4) International Coordinator, *International Network for Social Network Analysis* (INSNA). He also is a major historical figure in social network analysis, responsible for almost single-handedly creating INSNA (www.insna.org), which houses three of the field's top journals, *Social Networks*, *Journal of Social Structure* and *Connections*. Wellman's current research focuses on the structure and dynamics of network communities in cyberspace (Wellman and Haythornwaite 2002). Previous research, which connects him more directly to the second subcluster of research in CSNA (global network society) focuses on how people around the world develop and maintain local, personal networks in today's global society (Wellman 1999).

With the key scholars identified, we turn to a bit of history. The name for the new science of networks subcluster of research comes from a 2004 article that Duncan Watts wrote for the *Annual Review of Sociology*, titled, appropriately enough, *The "New" Science of Networks*. According to Watts, the new science of networks has the following profile:

- It builds “on a long tradition of network analysis in sociology and anthropology (Degenne and Forse 1994; Scott 2000; Wasserman and Faust 1994)” (p. 243).
- It builds on “an even longer history of graph theory in discrete mathematics (Ahuja et al. 1993; Bollobas 1998; West 1996)…” (p. 243).
- It is “spurred by the rapidly growing availability of cheap yet powerful computers and large-scale electronic datasets…” (p. 243).
- Its scholars come from a variety of disciplines, including “the mathematical, biological, and social sciences…” (p. 243).
- Its goal is to make “substantial progress on a number of previously intractable problems, reformulating old ideas, introducing new techniques, and uncovering connections between what had seemed to be quite different problems” (p. 243). Examples of intractable problems include the analysis of large-scale, complex networks, the study of the evolution and transformation of complex networks over time, and the study of how information, innovations, disease, cultural fads and so forth flow/move through complex networks (See Newman, Barabási and Watts 2006). Old ideas include affiliation networks, the small-world problem and community structure. New techniques include discrete mathematics, the power law, cellular automata and agent-based modeling. Cross-disciplinary connections include similarities in network structure at different levels of scale, from a protein to a human organization to an ecosystem.

The reader may recall, as we discussed in Chap. 5, the new science of networks typically is treated by popular reviewers as the latest and greatest topic in complexity science, with a slight nod to sociology (Buchanan 2002). It is because of this exegetical tendency that we placed the new science of networks on Map 1 at the far right-end of the complexity science trajectory.

The hermeneutical reality, however, is that the new science of networks is just as much a part of organized sociology as it is complexity science. Watts concedes this historical point in his 2004 article when he states that the label “new science of networks” may “strike many sociologists as misleading, given the familiarity (to social network analysts) of many of its central ideas” (p. 342). “Nevertheless,” he argues, “the label does capture the sense of excitement surrounding what is unquestionably a fast developing field—new papers are appearing almost daily—and also the unprecedented degree of synthesis that this excitement has generated across the many disciplines in which network-related problems arise” (p. 243).

In fact, Watt’s statement is so correct that we used it to add a sixth characteristic to the new science of networks profile: the scholars of the new science of networks are primarily interested in the structure and dynamics of networks; with only a secondary concern for substantive problems in social network analysis. If one looks, for example, at the 2,393 *Web of Science* publications that reference Watts and Strogatz's 1998 article, approximately 75% or more are in the subject areas of physics, mathematics, computer science, biology, and cognitive science. Many of these articles, in turn, use or apply their ideas to substantive topics in social network analysis. However, for the most part, their primary focus is the structure and dynamics of complex social networks in general—not sociology.

However, and once again, this empirical fact does not dismiss the importance of sociology to the new science of networks. While the study of complex social networks has become a major topic for complexity scientists (Buchanan 2002), and while these scientists (mostly physicists) have arrived at some incredible results through the usage of computational and mathematical modeling (Barabási 2003), these insights (all several thousand articles worth of them) do not trump or diminish the work that sociologists have been doing in social network analysis for the last thirty-five years (Bonacich 2002; 2004b; Freeman 2004; Morris 2004). For example, as Bonacich (2004b) and others have pointed out (e.g., Freeman 2004; Morris 2004), the complexity science literature repeats many of the insights of earlier social network research: small-worlds, short-cuts, weak links, centrality, clustering. Furthermore, the complexity science literature, while mathematically grounded, is theoretically lacking when it comes to understanding real-world networks. Again, Watts concedes this point: "Physicists may be marvelous technicians, but they are mediocre sociologists" (2004, p. 264).

Given these numerous shortcomings, why is the new science of networks part of SACS? Two reasons: First, as we already suggested, the new science of networks needs the substantive theories, concepts and real-world experiences of sociology. That is why so many of its scholars, from Watts to Newman to Barabási, have reached out to sociologists and their work. Second, whether mainstream sociology likes it or not, social network analysis needs the new science of networks. Despite all of the criticisms against complexity science, many sociologists realize the importance of integrating complexity science with social network analysis (Bonacich 2004a; Freeman 2004; Morris 2004). The new science of networks represents a much desired future for social network analysis and for addressing sociology's complexity: an interdisciplinary and international network of scientists, supported by a wide-ranging institutional structure, well-trained in applied mathematics and, more important, the computational techniques of agent-based modeling, thoroughly grounded in the theoretical and methodological traditions of sociology and social network analysis, epistemologically beyond the trappings of reductionism and the linear model of statistics, making use of very large databases, which they can employ for studying various aspects of our emerging global (network) society. As Bonacich states, "We are lucky that physical scientists and mathematicians have become interested in social networks. Of course we feel slighted; not all of our contributions will be noted. But this is the cost of moving onto a very much larger intellectual stage" (2004b, p. 4).

6.0.1.2 Global Network Society

If the new science of networks is distinct because of its secondary concern with topical application, the study of *global network society* is the exact opposite. It is almost entirely driven by its substantive concerns. Slightly modifying our original definition of CSNA, the goal of global network society is to study the structure and dynamics of global society through the theories and methods of network analysis.

It is because of this unique "network" approach that global network society not only holds a distinct position within CSNA and SACS, but also the globalization literature (Urry 2003). We can state this uniqueness as follows: While the new science of networks involves the realization that one can study very large, complex networks; global network society is the realization that global society is best viewed as a large, complex network, or, more accurately, a series of complex networks within networks within networks (Capra 2002). Let us explore this idea in greater detail.

To Globalize or Not to Globalize

The first and most difficult hurdle to jump in the globalization literature is not empirical but epistemological. Before one can ever consider the data, one must decide which view of globalization is correct. This sounds backwards, and it is.

Fact: the increasing interdependence of our global existence, including animal and plant, cannot be adequately contained within the confines of any one theory (Capra 2002). Globalization is too new, too fast and just too complex and overwhelming a force. Any theory, no matter how good, is underdetermined by the evidence. As such, no one theory holds sway. Instead, there are several competing views.

In his book, *Global Complexity*, Urry summarizes these views into one of several types—although none are mutually exclusive. First, there is *globalization as social networks* (Urry 2003, p. 4). All around the world, the social networks in which people participate are becoming less local and more global; and, in the process, these networks are transcending, undermining, overcoming and deflating traditional networks defined by one's nation, state, culture or economy. The most poignant example is the new trans-national world of business, with its corresponding world-wide network of banking, raw materials, and product distribution. As leaders in the business community, these individuals work all over the world; as parents they send their children to international baccalaureate programs; and as private citizens they secure their retirement in one country, buy their homes in another; and have friendship networks that span the globe.

The second is *globalization as information technology* (Urry 2003, pp. 4–5). Information technology—cells phones, computers, microchips, smart machines, faxes, the internet, the World Wide Web, satellites, televisions, etc—has radically altered the geography of modern life, undermining the modernist notions of time-space, including the creation of an electronic world community (Wikipedia, Myspace.com, YouTube, etc). Variants of this view include Freidman's (2007) the-world-is-flat perspective.

Perhaps the most optimistic view is the third: *globalization as neo-liberal ideology* (Urry 2003, pp. 5–6). Depending upon one's country of perspective, this view alternatively is labeled as neo-conservative (USA), neo-liberal (England) or western (South America). Whatever the label, the view is that globalization represents the gift of western society to the rest of the world, including its businesses, capitalism, democracy, and civil rights. Globalization is great because it "frees up" markets and economies so that capitalism, along with its economic, cultural and political benefits can be more globally fluid.

The fourth is *globalization as performance* (Urry 2003, pp. 6–7). This view focuses on cultural transformation, with the hope of bringing forth in people a global conscience and a global humanity. From this perspective, globalization is cultural praxis. It is a tool for changing how people act, including their behaviors toward oppressed and marginalized people, inequality, the environment, working conditions, and so forth. The *global warming* movement and the related work of Al Gore is an example of this type of globalization.

The final perspective is *globalization as a complex system* (Urry 2003, pp. 7–8). This is, generally speaking, the perspective of those working within the area of global network society. The most widely known scholars include Immanuel Wallerstein, Manuel Castells, John Urry and, to a lesser extent, Barry Wellman.

Is the Entire World a Complex Network?

The GSN literature is massive, both in its ambitions and in its verbiage. First, there are the ideas themselves, which includes the work of Immanuel

Wallerstein and his groundbreaking world systems theory. As we explained earlier in our discussion of the Gulbenkian Commission, Wallerstein's work did not begin in complexity science. Instead, it emerged out of the intersection of three major influences.

The first influence is the great French Historian, Fernand Braudel, from whom Wallerstein develops his idea of the longue durée (large historical cycles) and the extensive network structure of global capitalism.

The second influence is dependency theory, from which he creates his notions about the way dominant, hegemonic countries (particularly those in the west) exploit peripheral, agrarian-based societies, such as those in the south and the east. Here, Wallerstein claims that globalization is a euphemistic term for the global encroachment of western capitalism and the capitalistic machine. This view, which focuses entirely on the world economy, could equally be called an anti-globalization perspective.

The third influence is global Marxism. Traditional Marxists (particularly in sociology) focus on the structure and dynamics of social class as it takes place within particular nation-states such as England during the 1800s. Wallerstein focuses on the *fin de siècle* of capitalism: colonial-imperialist relations at the global level.

By interlacing all three influences, Wallerstein creates a stunning conceptual and visual map of the world and its countries, which he divided into three tiers: core, semi-peripheral and peripheral. The core has all the resources and power and the periphery has little to none; the semi-periphery is somewhere in the middle. Using this geographical lexicon, Wallerstein has, over the years, examined the structure and dynamics of this three-tier system, primarily along economic lines, with profound insights. Within the past decade, he has pulled into his theoretical framework concepts from complexity science, talking about the world system in terms of bifurcation points, perturbations, chaos and turbulence, networks, emergence and self-organization (2004, 2005).

With over seventeen books and numerous articles, essays, lectures, invited speeches and commentaries, Wallerstein is one of the most influential scholars in sociology and the globalization literature, only outdone by our second scholar, Manuel Castells. At present, Castells is one of the most widely cited scholars in sociology, with over 3,000 citations on *Social Science Citation Index*.

Castells is best known for his monumental trilogy, *The Information Age: Economy, Society and Culture*—originally published by Blackwell between 1996 and 1998 and revised and published as a second edition between 2000 and 2003. The premise of this trilogy (and subsequent works) is that a new form of social structure has emerged, which Castells calls *network society*.

There are three causal mechanisms responsible for network society, all of which took place during the last thirty years of the 20th century: (1) the counter-culture movements of the 1960s in North America and Western Europe; (2) the "socioeconomic restructuring of both capitalism and statism" (Castells 2000, p. 694); and (3) the computer and information revolution, which has increasingly spread to the east and the south. Of these three, the information revolution is the most important, hence the title of his trilogy, *The Information Age*.

Castells' emphasis on western society's shift to information technology parallels the thesis of Daniel Bell's *The Coming of Postindustrial Society* (1974/1999). This thesis is as follows: the computer and information revolutions have changed the world. Unlike Bell, however, Castells does not confine his inquiry to western society. Furthermore, Castells has the advantage of time. Bell published his work in 1974, with a slight revision in 1999. Castells published his trilogy in the late 1990s, just as the internet, World Wide Web, and so many other forms of information technology were gaining momentum. Finally, Castells does not argue that the information revolution caused network society; instead, network society capitalizes on the information revolution.

Network society is historically unique because it responds to and makes extensive use of information technology to create new forms of economic, political and cultural organization. Network society is also unique because these new forms of organization are creating a new global network and corresponding geography. The term "network" therefore explains two things for Castells.

First, it explains "how" people use information technology to transcend traditional notions of time-space to connect with others around the world. Here, one thinks of people who are good at "networking" with others, including power lunches, passing out business cards, winning friends and influencing people. At the global level, networking extends to the behaviors of businesses, formal organizations and so forth. These connections can be economic, as in the case of the global economy; they can be political, as in the form of new activist movements; or cultural, as in the form of internet communities and virtual reality. In all three instances, the traditional boundaries of nation, state, culture, and identity are transcended (at least partially) to create new forms of social organization. And, what do these new forms of organization look like when plotted? Here is the second thing networks explain. They look like complex, technology-based, dynamic, fragmented, chaotic, flowing, self-organizing, autopoietic, open-ended, emergent, global, social networks.

With these two aspects of network explained, we come to a major point for Castells. Globalization is not the process of the current world, as we know it, becoming a smaller place. Little in the data suggests this to be true. Traditional forms of society have not gone global. Instead, the opposite has happened. The traditional forms of society are beginning to disappear and are being replaced by network society. Stated another way, globalization represents the emergence of network society. It is network society that has gone global.

Here we come to another major point for Castells. As network society increases its global hold on the world, its new forms of economy, politics and culture are clashing with older, traditional notions. These clashes have major consequences for our globe, including (1) the slow collapse of the nation-state, (2) a reactionary rise in fundamentalism, (3) the backward-looking emergence of nationalist identities, (4) a growing divide between the information class and the rest of the world, (5) the partial breakdown of the welfare state, and (6) increasing difficulties in monitoring, controlling and regulating network society as it ebbs and flows between order and chaos, regularity and disaster.

Interestingly, Castells' solution for these global social problems, along with the information revolution that is fueling them, is more networks. According to Castells, network society has emerged because it provides people a level of flexibility and adaptability that the older forms of economics, politics and culture do not. Think, for example, of businesses outsourcing their work—or of international trade, global markets, internet-based communities or electronic trading—all powerful ways to handle or capitalize on the information revolution to get ahead in business. Likewise, we have activist groups around the world using the internet and telecommunications to momentarily cluster together for such things as Earth Day or the World Trade Organization meetings. Then there is the ability of people to use the internet to open-up and undermine the totalitarian states in which they live. Like the Ouroboros eating its own tail, network society feeds off itself. Network society is the best way to respond to and make use of the information revolution, which, in turn, accelerates the expansion of the information revolution, which leads to more network society, and so on. This, Castells argues, along with its conflict with the older forms of society, is the globalization phenomenon.

John Urry, our third major theorist, could not agree more. In fact, he is willing to take Castell's argument one step further. Not only is network society real, it has become a massive, world-wide, complex system: self-organizing, bifurcating, autopoietic, emergent, chaotic, unstable, operating far-from-equilibrium. In 2003, Urry published the first full articulation of his view in his book, *Global Complexity*. This was not, however, his first swing at the topic of globalization. Urry has been at the business of studying globalization for quite some time, including the publication of a long list of rather provocative books and papers, earning him over 500 citations. In his work, which runs from such topics as *The Tourist Gaze* (1990) and

Consuming Places (1995) to *Mobile Sociology* (2000a) and *Sociology Beyond Society* (2000b), Urry does not try to shock or impress readers with his usage of the latest theoretical trick or methodological gadget. As he explains in his opening statement to *Global Complexity* (2003), he draws upon new ideas in hopes of improving his sociological imagination. This is the hope that led him to complexity science and, from there, to the idea that globalization (or, more specifically, Castell's global network society) is best viewed as a complex system.

During the course of his research, Urry found himself struggling to make sense of the massive complexity associated with globalization. As a consequence, Urry began to read the complexity science literature. This led him to realize that while the current globalization literature has done a great job highlighting and developing our understanding of the world today, it ultimately is doomed to failure because it lacks a sufficient theory of global complexity. Fortunately, the field of complexity science, when effectively integrated with sociology, provides just such a theory. Urry had the beginnings of a new framework. In *Global Complexity* (2003) he explores this new framework.

At this point a caveat is necessary. Because Urry's ideas are in the initial stages of development, *Global Complexity* (2003) is more of a work-in-progress than a formal statement. It is not well defended empirically and it is not a systematic treatise. Instead, Urry's purpose is more focused. He wants to get the reader to consider the idea that global network society might be a complex system. If Urry is correct—which can only be established by rigorous empirical study—he will have provided a major breakthrough in our understanding of the new global world in which we live.

6.1 Computational Sociology

The main methodological cluster of SACS is computational sociology. It has the following *web of social practices* profile.

Complexity Science Lineage: The most fascinating aspect of computational sociology is the extent to which its historical trajectory parallels the development of complexity science method, including the intellectual traditions upon which it draws (Gilbert and Troitzsch 2005). In fact, computational sociology looks remarkably similar to the methodological trajectory we outlined in our review of complexity science method in Chap. 5. Because of this parallel, we refer to computational sociology as a microcosm of complexity science method.

As stated in Chap. 4, computational sociology is a *branch* of sociological inquiry: a formal sub-field extending outward across the discipline into new territories. Since the 1950s when it first emerged, computational sociology has mimicked the methodological developments of systems science and cybernetics, and still later complexity science (Gilbert and Troitzsch 2005). This includes drawing upon and (in some cases) developing key areas within modern mathematics, computer science and artificial intelligence such as graph theory, matrix algebra, structural modeling, distributed artificial intelligence, system dynamics, game theory, computational modeling, fuzzy logic, and agent-based modeling (Halpin 1999).

For example, the first article in computational sociology was published in 1957 by Guetzkow and Bowes "The Development of Organizations in a Laboratory" (See Halpin 1999, p. 1504). Five years later Guetzkow went on to publish an edited work titled *Simulation in Social Science: Readings* (1962), which included James Coleman's "Analysis of Social Structures and Simulation of Social Processes with Electronic Computers." For readers new to this area, Coleman is a major historical figure in SACS, including his pioneering work in mathematical sociology, rational choice theory, social network analysis and computational sociology. Of particular note is his 1964 classic, *Introduction to Mathematical Sociology.*

As Halpin points out (1999), these early works on computational sociology use or reference many of the development in computational methods at the time, including discrete events modeling and computer gaming. To create a context for the reader, during this same time period (late 1950s to early 1960s) Prigogine introduced his concept of dissipative structures, Wiener published *The Human Use of Human Beings* (1956), Ashby published *Introduction to Cybernetics* (1956), McCarthy and colleagues held the first artificial intelligence conference at Dartmouth (See Chap. 4) and Forrester created systems dynamics—the equation-based, simulation technique most sociologists and social scientists used during this time period (Gilbert and Troitzsch 2005).

For the next forty years, computational sociology would continue to mimic the intellectual lineage of complexity science method, including years of existing on the margins of mainstream social scientific inquiry (Macy and Willer 2002; Gilbert and Troitzsch 2005). As Halpin points out, "Computer simulation has played a significant, although secondary, role in sociology almost as long as sociologists have had access to computers…. However, simulation has waxed and waned in prominence and has always stood apart from the mainstream of sociology, which has not fully appreciated its contribution" (p. 1488). It is somewhat sad and discouraging that the very methods and techniques responsible for so many advances in the natural sciences, along with an important role in the development of the computer, computer science, the internet, the World Wide Web, and in many ways globalization, remained for so long on the margins of social scientific inquiry. But, that is another story. Fortunately, things are changing, thanks to the rising vogue of agent-based modeling. One example is the 2005 Special Edition of the *American Journal of Sociology*, entirely devoted to the history and usage of computational sociology and agent-based modeling.

Complexity Science Topics: There is little in complexity science that computational sociology does not explore (Miller and Page 2007). The only exception is the study of substantive areas such as physics, chemistry and biology. The main themes we discussed in Chap. 5, however, are all addressed: self-organization, autopoiesis, emergence, system dynamics and social networks. For example, of the 273 articles listed on the *Web of Science, Social Science Citation Index* (Accessed Feb 2008) for the *Journal of Artificial Societies and Social Simulation*, all of the major themes in complexity science are addressed, with the most popular being system dynamics (N=18) and networks (N=14).

Sociological Topics: As Miller and Page (2007) and others have acknowledged (e.g., Gilbert and Troitzsch 2005), substantively speaking, computational sociology is very diverse. Its work is all over the place. Not only is computational sociology heavily interlaced with the intellectual traditions and topics of systems science, cybernetics and complexity science, it also crosses a wide array of disciplinary boundaries in the social sciences, ranging from business, political science and public policy to epidemiology, economics and demography to small-group dynamics, ecology and organizations to social networks and environmental and urban planning (Gilbert and Troitzsch 2005; Halpin 1999; Macy and Willer 2002).

An example of this interdisciplinary impulse is Axelrod's review of the 2002 *Web of Science, Social Sciences Citation Index.* While Axelrod found a total of 77 publications for the keyword "simulation," they were published in 55 different journals. The establishment of the *Journal for Artificial Societies and Social Simulation* (as well as *Computational and Mathematical Organization Theory*, *Sociological Methods and Research* and *Behavioral Science*) has gone a long way toward consolidating the research of computational sociology, but the interdisciplinary impulse remains strong.

Another example of this interdisciplinary impulse is computational sociology's name. Depending upon the reviewer, computational sociology is: (1) a branch of sociology (e.g., Macy and Willer 2002); (2) part of some other social science discipline such as computational economics (Miller and Page 2007); or (3) part of the larger field of computational social science (Axelrod 1997; Gilbert and Troitzsch 2005; Halpin 1999).

As a final example, many of the leading scholars in computational sociology are simultaneously situated within different areas of study. Scott Page, for example, is a Professor of Political Science, Complex Systems and Economics at University of Michigan. He is also former director of the *Center for the Study of Complex Systems* at Michigan and an external faculty member of the Santa Fe Institute. Currently, he is one of the rising stars in complexity science and computational modeling (Miller and Page 2007; Page 2007). However, depending upon the reviewer, he is a computational economist, complexity scientist, or computational social scientist. The same conflation is true of Page's colleague at Michigan, Robert Axelrod. Like Page, Axelrod is heavily involved in political science, economics and complexity science, and is variously associated with computational modeling in general, computational social science, computational economics, and computational sociology. We can keep going. Another colleague at Michigan is John Holland, the creator of genetic algorithms and leading historical figure in complexity science. Again, depending upon how his work is approached, he has been situated in all the computational fields we have so far mentioned.

As these examples illustrate, the reason the boundary lines between computational sociology and the various other areas of computational analysis are so often blurred is because their intellectual traditions, topics of study, and areas of substantive research parallel each other to a profound extent. This parallel even continues into the intellectual traditions of sociology.

Sociology Lineage: Both computational sociology and complexity science method draw upon a long list of intellectual traditions within sociology, most of which are micro-level in their orientation: rational-choice theory, exchange theory, symbolic interaction, ethno-methodology, and (at a slightly more meso-level) the sociology of formal organizations. Much of this orientation toward micro-sociology comes from the heavy influence economists and political scientists such as Axelrod and (more recently) Page (2007) and Epstein (2007) have had on computational modeling, as well as the current intractability of modeling large-scale social systems (Axelrod 1997).

There is, however, an emerging meso/macro level literature in computational sociology and complexity science method, which is focused on developing a rather sophisticated sociological understanding of the scalability of large social systems (Fischer, Florian and Malsch 2005). This area goes by the name of *socionics*. As Fischer, Florian and Malsch explain (2005), socionics focuses on several important themes: (1) transforming sociological theories and concepts into computer models; (2) examining the link between the scalability (a.k.a. emergence) issue in computational modeling and the micro-macro link in sociology; and 3) using sociology to develop the tools of computer science (Klüver 2000, 2002). If one were to locate socionics on our network of attracting clusters (Map 4), it would be a 2nd order sub-cluster within simulation, which is one of the three major sub-clusters of study in computational sociology.

Complexity Science and Sociological Method: While the above parallels between computational sociology and complexity science method are important, the most significant parallel is the methodological repertoire and lineage of these two areas. Both computational sociology and complexity science are a genealogical hybrid of mathematical modeling, statistics and simulation. In fact, every single area within computational modeling and complexity science method can be easily linked to one or more branches on this genealogical network. Consider, for example, the following.

1. Statistics: The first major genealogical branch in computational sociology is statistics. In addition to the traditional branches associated with this methodology (regression, factor analysis, analysis of variance, etc.) statistics includes a specific sub-set of techniques highly applicable to modeling social systems, including structural equations modeling, k-means clusters analysis and discrete events analysis. There also is computer simulation within statistics, as demonstrated in Monte Carlo studies. The most important area within this genealogical areas, however, is the development of neural networking, decision trees, and the new field of data mining (Castellani and Castellani 2003; Castellani, Castellani and Spray 2003). Data mining also is one of the rising subfields of study within computational sociology.

2. Mathematical Modeling: The second major genealogical branch is formal mathematical modeling, which is comprised of three additional arms. The first is the *mathematics of structure*, which leads to the development of structural analysis, social network analysis and eventually the new science of networks. Readers may not realize it, but social network analysis actually began (and in many ways remains) a field of formal mathematical modeling—graph theory, game theory, etc—created to model the structure of social groups (Scott 2000). That is why one of the leading journals in social network analysis is called *Journal of Social Structure* (www.insna.org/). In fact, it is because of its strong connection to structural mathematics that social network analysis "discovered" many of the insights later developed and made popular by scholars like Watts and Barabási.

In mathematical modeling, the second major branch is the *mathematics of processes*, which is further subdivided into deterministic and stochastic mathematics (Weidlich 2000). Genealogically speaking, deterministic processes leads to differential equations and difference equations—what complexity scientists refer to as a top-down, macro-level approach to modeling complex systems—as opposed to a bottom-up, agent-based perspective (See method section of Chap. 5).

In stark contrast to this deterministic approach is the genealogy involved in the study of stochastic processes, which leads to Markov chains, Brownian motion, dynamical systems theory and (more specifically) chaos theory and fractal geometry—all of which eventually tie into simulation and computational modeling and from there into agent-based modeling. This genealogical arm also leads to the second major subfield of study in computational sociology: dynamical systems theory, as in Gunduz's application of fractal scaling to the growth of the Ottoman and Roman empires (2000, 2002) and Abbott's fractal analysis of the chaotic, scale-free behavior of the social sciences (2001).

The third major genealogical branch in formal mathematical modeling is the *mathematics of actors and agents,* which leads to game theory, rational choice theory, data mining, evolutionary game theory, and (amazingly enough) the integration of mathematics with qualitative data analysis—examples of the latter include soft modeling, fuzzy-set social science, and the integration of neural networking with qualitative method (Castellani, Castellani and Spray 2003; Castellani and Castellani 2003).

3. Simulation: The final major genealogical branch is simulation, which can be broken down into two major arms: equation-based modeling and computational modeling. The first arm leads to system dynamics and the work of Forrester and is strongly connected with deterministic mathematical modeling, which takes us to calculus and, more recently, control theory. The second arm basically is a rehearsal of everything we discussed about the history of agent-based modeling in Chap. 4, including distributed artificial intelligence, cellular automata, etc. Genealogically speaking, this final area also leads to the third major sub-cluster of study in computational sociology: simulation.

4. Putting it all together: When all of these genealogical areas are brought together, you get Map 5 (See Chap. 10). To create this map, we did the following.

First, we read all of the major reviews on computational sociology and its related areas, including mathematical sociology and sociological game theory. These reviews included Axelrod (1997), Epstein (2007) Gilbert and Troitzsch (2005) Halpin (1999) and Macy and Willer (2002), Swedberg (2001) and Troitzsch (1997). Next, for each of these reviews we constructed a methodological genealogy, including all the major lineages, areas of study, key scholars and major and minor techniques identified. From here, we looked for similarities amongst the reviews and their respective genealogical trees. Fourth, we took the different genealogies and integrated them to create a final tree. We then entered this information into the social network software package *Pajek* (pajek.imfm.si/doku.php). From here we conducted a vector analysis, looking for the hubs and main authorities in our genealogical tree of computational methods. We then used Pajek to create a visual representation of our network. As shown in Map 5, the larger the node for a particular method or the closer it is to the center of the graph, the more important it is to computational sociology. We then compared Map 5 with our review of complexity science method to examine their similarities. One will note, for example, that on Map 5 the most important areas are computational modeling, agent-based modeling, actor/agent mathematics, the study of stochastic processes, structural mathematics (social network analysis) and statistics. This map captures quite well our review of the lineage of complexity science method. Based on our analyses, we concluded that: (1) computational sociology is a microcosm of complexity science method; and (2) the parallel between these two areas is a function of their shared lineages, theories, topics and methods.

6.1.1 What Makes Computational Sociology Unique

Now that we have a good sense of what makes computational sociology similar to complexity science method, we need to discuss what makes it unique. Despite its strong interdisciplinary impulse, and despite its parallels with complexity science method, the fact remains that scholars created computational sociology to study social systems. This substantive focus does not mean the insights of computational sociology do not transfer to the natural or computational sciences. Case in point: a specific goal of socionics is to transfer the theories and concepts of sociology to advance the field of computer science by exploring how, for example, humans can be of assistance to computers (Fischer, Florian and Malsch 2005). Still, despite all this transfer, the fact remains that human social systems are, to a certain extent, isomorphically unique.

It is this uniqueness that forms the basis for computational sociology's distinct approach to its work. Human social systems present two major challenges to those who would model them. The first is the unparalleled intelligence of human social agents and the second (which comes from the first) is the astonishing complexity of the systems human agents create.

One of the most complex biological systems on the planet is the human brain. Put 6 billion of these brains together, along with the global network they create, and the product is even more complex. Going further, if one proceeds to examine the myriad of social systems this network of human brains create, along with the unlimited ways these systems interact and impact one another, let alone the relationships these interacting systems have with the biological and physical world, and one has a major methodological challenge (Gilbert and Troitzsch 2005). It is this methodological challenge that defines the purpose of computational sociology.

6.1.2 Three Subfields of Study

Currently, computational sociologists have developed three major approaches to the study of social systems. The first and most widely practiced is social simulation, followed by data mining and then dynamical systems theory. Because we already surveyed these three methods in Chap. 5, our review here is more specific, focusing on key scholars, journals, conferences and unique research projects.

6.1.2.1 Social Simulation

As Halpin (1999) and others have explained, although the tools and techniques of social simulation have been around since the 1960s, it only is recently that social simulation has ascended from its marginal status within sociological method to a position of relative prominence (Cederman 2005; Gilbert 1999; Gilbert and Troitzsch 1997; Macy and Willer 2002).

The growing popularity of simulation is due, in part, to the development of agent-based modeling, high-powered personal computers, and new software platforms. It is also due to the hard work of a small list of scholars and the numerous world-wide conferences, journals and areas of study they have worked very hard to develop.

The most important periodical in social simulation is *Journal of Artificial Societies and Social Simulation* (JASSS). Since its inception in 1998, JASSS has had over 6 million successful hits (information accessed 26 January 2008), with an average daily hit rate of just over a thousand (jasss.soc.surrey.ac.uk/JASSS.html). On its website, one can also find a java-based diagram of every JASSS articles and its citation links with all other JASSS articles. There is also a “Top 20” list of the most viewed articles. The JASSS citation network and Top-20 list provided a useful window into current trends in simulation. For example, in terms of the “Top 20” list we examined (26 January 2008), half of them dealt with methodological and theoretical issues and the other half substantive topics. Specifically, five articles reviewed or discussed how to do simulation; three articles explored how to model highly complex social systems; two used simulation to advance sociological theory; and the other ten examined various empirical topics such as youth culture, pandemics, cooperation, kinship networks and human language. The JASSS articles most highly cited by other JASSS articles revealed a similar pattern. These highly cited articles focused on simulation techniques and the dynamics of complex systems, followed by various empirical topics such as simulating opinion polls and disease networks.

These two data patterns at JASSS also corroborate a major point we will develop in the next two chapters. Simulation, like much of the research in SACS, is in the early stages of development, with scholarly work significantly divided (almost equally) between developing the methods and theories researchers need to guide their inquiries and actually doing empirical research, including the usage of simulation to develop theory.

Of the numerous scholars in simulation, several are worth mentioning here. The first is Professor of Sociology at University of Surrey (UK), Nigel Gilbert. Not only is Gilbert the creator and Editor of JASSS, he also is Director of the *Centre for Research in Social Simulation*. (http://cress.soc.surrey.ac.uk/). Gilbert's work in simulation revolves around one dominant theme: tirelessly championing computational modeling as a legitimate method for sociological research. Like Barry Wellman, Gilbert is an authority. The list of accomplishments he has amassed in the pursuit of this connecting vision is impressive, including his involvement in just about every major European conference and world-wide association in the field of social simulation, as well as editing, writing or co-writing numerous articles, technical reports and handbooks on simulation (Gilbert 1999, 2000; Gilbert and Troitzsch 2005).

Another key scholar is Gilbert's co-editor and co-author, Klaus G. Troitzsch, University of Koblenz-Landau (Germany). Like Gilbert, Troitzsch is a pioneer in the development of computational sociology and is involved in just about every aspect of the field, from his work as Forum Editor of JASSS to his involvement in the massive *European Social Simulation Association* to his co-publications with Gilbert (Gilbert and Troitzsch 2005) to his development of various new techniques for simulation.

Other key scholars in social simulation include: (1) Jürgen Klüver (2000) and colleagues (e.g., Klüver, Stoica and Schmidt 2003) who are working on a mathematical, agent-based theory for the study of social complexity and communication; (2) Christopher Goldspink, who has been developing a metatheoretical framework for modeling complex social systems (2000, 2002); (3) Philip Bonacich, who (as we discussed earlier) is a key figure in network theory and mathematical sociology; (4) Joshua Epstein and Robert Axtell (1996), well-known for their concept of generative social science and their work on growing artificial societies; and (5) Joerg Strübing (1998) and colleagues (e.g., Fischer, Florian and Malsch 2005), who are part of a network of researchers interested in the interface between sociology and multi-agent systems research (MAS). The name for this emerging field, as we mentioned earlier, is *socionics* (Müller, Malsch and Schulz-Schaeffer 1998). Strübing is specifically interested in integrating multi-agent systems with the symbolic interactionist work of Anselm Strauss (1993).

6.1.2.2 Data Mining

As we explained in Chap. 3 of this section, data mining is a data-driven, exploratory process of knowledge discovery and database management that uses various methods in statistics, mathematical modeling and simulation to discover meaningful patterns of relationship in large electronic databases (Berry and Linoff, 2000; Castellani and Castellani 2003). The advantages of this method for sociologists are several: (1) it can qualitatively analyze quantitative data; (2) it can focus on social processes and relationships; (3) it can work well with existing qualitative techniques, such as grounded theory; and (4) it can handle nonlinearity, data noise and conceptual fuzziness.

Surprisingly, despite the overwhelmingly widespread application of data mining in the disciplines of business, economics, education, health care and computer science, it remains an underdeveloped area in computational sociology, SACS, and sociology in general. Given the increasing challenges sociologists face in managing and studying the massive electronic databases now available to them, it is amazing that these techniques remain on the margins, pointing once again to the need for a major overhaul in the methodological component of sociology departments. For more information on the utility of data mining, particularly its integration with qualitative method, please see Castellani, Castellani and Spray (2003) and Castellani and Castellani (2003).

6.1.2.3 Dynamical Systems Theory

Of the three areas, this is the least used. However, thanks to the work of Gunduz (2000), Abbott (2001), Ragin (2000) and Weidlich (2000), this subfield of computational sociology has achieved some impressive insights. For example, Gunduz (2000, 2002) and Abbott (2001) have explored how fractal scaling and self-organized criticality relate to sequencing and social change. The work of Charles Ragin (2000) focuses on the relationship between fuzzy logic and case-based research—a major impetus for our development of the SACS Toolkit and the case-based approach of assemblage. Finally, Wolfgang Weidlich (2000) makes significant strides in the usage of systems nonlinear dynamics (formal mathematical modeling) to model a variety of social processes—from political transitions and group interactions to urbanization and evolutionary economics.

For an excellent review of the potential of dynamical systems theory, specifically chaos theory, for modeling social systems, we recommend Eve, Horsfall and Lee's edited book, *Chaos, Complexity and Sociology: Myths, Models, and Theories* (1997). Although it was published over a decade ago, it outlines the value of chaos theory for sociological inquiry. From there, we recommend reading Weidlich's *Sociodynamics: A Systematic Approach to Mathematical Modeling in the Social Sciences* (2000). Although the latter is highly mathematical, it concretely demonstrates how chaos theory and, more generally, formal mathematical modeling, can be used to examine complex, chaotic social processes. Additional mathematical works to read include Bar-Yam (1997) and Boccara (2004).

6.2 British-based School of Complexity

While all five research areas in SACS endeavor to make significant advances in the normative work behaviors of mainstream sociology, none is more ambitious or radical than the British-based School of Complexity (BBC). The BBC is not just interested in revising or advancing the current practice of sociology. It seeks an entire reformulation of its theories, concepts, methods and organizational arrangements, based primarily on the latest advances in complexity science. It is because of this comprehensive reformulation from a particular perspective that we refer to the BBC as a school of thought: a defined way of doing work based on a particular scholar or group of scholarly ideas, which has a shared identity, common vocabulary, mutual methodology and similar topics of study. To make sense of the BBC's reformulation, we will review its *web of social practices* profile.

6.2.1 Complexity Science Lineage

The first major goal of the BBC is to create a post-disciplinary sociology. By post-disciplinary we mean the following. The word "post" refers to any type of sociology that goes beyond the discipline's current institutional arrangements and intellectual divisions. These "post" disciplinary arrangements can be inter-disciplinary (between or amongst disciplines), trans-disciplinary (above and beyond disciplines) or even anti-disciplinary (without disciplinary boundaries). By disciplines we mean "competing and autonomous groupings of researchers and teachers that are, in crucial respects, historically arbitrary" (Scott 2005, p. 136). Disciplines exist through their institutional backing, primarily in the form of financial support. Disciplines also exist because of their institutional control over the granting of degrees (in particular the doctorate) and the conferring of credentials. Disciplinary and institutional boundaries, particularly in the social sciences often bear little resemblance to their associated intellectual divisions. Intellectual divisions are clusters of shared themes, concerns, topics, methods and lineages, which often cross over or repeat themselves within various disciplines. Examples include the study of social psychology, gender and inequality in such disciplines as sociology, psychology, economics, education, business and medicine. At their most extreme, intellectual divisions (particularly when they are ignorant of one another) lead to hyper-specialization and the creation of scholarly cul-de-sacs.

The BBC's goal to overcome the disciplinary boundaries and institutional and intellectual divisions of contemporary sociology connects it to a long-standing tradition of post-disciplinary thinking in systems science, cybernetics and complexity science. To see the BBC's connection to this tradition, let us take a detour into a bit of this tradition's history.

The reader may recall from Chap. 5 that, going as far back as the 1940s, the goal of systems science has been to unite the natural and social sciences under the common banner of systems thinking. This goal is reflected in the variety of disciplines involved in systems science, from biology (Ludwig von Bertalanffy) and anthropology (Margaret Mead) to psychiatry (James G. Miller) and engineering (Claude Shannon) to mathematics (Walter Pitts) and economics (Kenneth Boulding). It is also reflected in the bylaws of systems science's major organization, the *International Society for the Systems Sciences*: "(1) to investigate the isomorphy of concepts, laws, and models from various fields, and to help in useful transfers from one field to another… (4) to promote the unity of science through improving communication among specialists" (isss.org/world/index.php). Finally, it is reflected in sociology through the intellectual and institutional goals of Parsons and the Department of Social Relations at *Harvard University*.

There is a good reason why systems science, cybernetics and complexity science have been so successful at creating a post-disciplinary science. It has to do with their approach.

The common-but-doomed method of fostering unity across the sciences has been to call for some type of disciplinary dissolution, such as no more academic departments, or for some type of hyphenated, bio-psycho-social institutional program. Systems science considers these moves moot. Instead, systems science focuses on the intellectual divisions of science. System science argues that, while hyper-specialization may be a necessary evil of empirical inquiry, it alone does not science make. At some point scientists need to address their common theme: the growing complexity of scientific work and the need for a systems perspective to address it. While the topics of science can be divided, broken down and reduced in an effort to grasp them initially, the real success of science will only come when these topics, in all of their complexity, are put back together and studied as systems. Science is ultimately the study of complex systems.

Slowly but steadily, the natural and computational sciences have begun to embrace this “complex systems” theme, which is currently spreading rather well across their various departments and schools. As a consequence, the disciplinary divisions of the natural and computational sciences are beginning to seem less important.

The same is not true of main street sociology—this point moves us closer to the post-disciplinary thinking of the BBC. Main street sociologists have ignored the systems tradition for so long that they do not seem to appreciate the paradigm shift to systems thinking taking place in the natural and computational sciences, ranging from physics and systems engineering to the human genome project and systems biology to environmental planning and systems ecology to computer science and the rapid development of multi-agent systems (Capra 2002; Érdi 2007; Hammond 2003; Klir 2001). Lacking a systems perspective, most sociologists also do not see or understand why disciplines like physics and biology are branching outward into sociology and other domains of social scientific inquiry. Instead, they see these post-disciplinary movements as an encroachment into their “sacred” domains of inquiry, which must be dismissed or defended against (Bonacich 2004a; Watts 2004). Most important, however, sociologists do not see the spread of systems thinking into their own discipline. As such, they do not see the purpose of the BBC’s call for a post-disciplinary sociology. In fact, most sociologists probably see the BBC’s claims as dreadfully unnecessary, fancifully absurd, or well-intended but doomed. Nothing, however, could be further from the truth.

Now, we are back finally to the BBC. Like systems science, cybernetics and complexity science (or the Department of Social Relations at Harvard some thirty years ago), the goal of the BBC is to create a post-disciplinary sociology grounded in the theme of complex systems. As we articulated in our introductory chapter, this theme goes as follows: (1) in the last two decades the complexity of western society has reached a tipping point; (2) this tipping point has resulted in a major phase shift in the organization of global society; (3) this phase shift is, in large measure, a function of the computer revolution, post-industrialization and globalization; (4) the consequences of this phase shift (environmental collapse, global economics, cultural and political conflict, etc) cannot be adequately addressed by the normal tools of sociology; (5) new tools are needed, grounded in a systems perspective and the latest advances in computational modeling and mathematics; (6) complexity science is therefore the future of sociology (Byrne 1998; Luhmann 1995; Urry 2003).

The most outspoken scholar advocating for a post-disciplinary sociology is John Urry (2000). As one of the leading sociologists in the BBC, Urry has been consistent in his argument for a new sociological imagination grounded in the tools of complexity science. His argument is a variant of the above theme we just stated, with emphasis on two key aspects of it: (1) the rise of global network society and (2) the growing complexity of sociological work (Urry 2000).

As we discussed earlier, following the work of Castells, Urry (2003) argues that network society has gone mobile, and is transforming itself into a massively complex global system. The only hope for studying this complex social system is to transform the tools of sociology by critically integrating them with the latest advances in complexity science. This transformation and critical integration require sociologists to move out of their intellectual comfort zones, to seek the margins of the discipline, and to explore new intellectual terrain, all in the hopes of collaborating with scholars and ideas from the rest of the sciences and the humanities (Urry 2000).

There is a caveat, however. Contrary to what one might expect, Urry's post-disciplinary sociology is not a call for the collapse of organized sociology. Far from it. While Urry agrees wholeheartedly with Wallerstein, Prigogine and the Gulbenkian Commission that sociologists need to unite with the rest of the sciences under the common banner of complexity and systems thinking, he does not think much of the idea of sociology becoming an interdisciplinary social science. Remember, systems science goes for intellectual not disciplinary change. Following this line of thinking, Urry is not seeking the demise of the sociological enterprise. Instead, he seeks mobility.

If society has gone mobile, so must sociology and more specifically sociologists. Citing the work of Dogan and Pahre's *Creative Marginality* as an example (1990), Urry explains that most innovations in the social sciences today take place at the margins (Urry 2000). That is why places like SACS and the BBC are built on the outer banks of sociology: the marginality of these intellectual towns and communities allow for tremendous cross-disciplinary movement and creative synergy. Unexpectedly enough, however, creative marginality needs a firm disciplinary foundation upon which to build its bridges of innovation—Urry takes this point from Dogan and Pahre (1990). SACS and the BBC, for example, can only be post-disciplinary because the outer banks of sociology (despite their permeability) are disciplinarily stable. In other words, the discipline of sociology does not need to go mobile; sociologists interested in addressing the complexity of their work need to go mobile.

While not a member of the BBC, another of our millennial scholars, Andrew Abbott, whom we discussed back in Chap. 5, agrees with Urry. If we recall his argument, Abbott sees very little evidence to suggest that organized sociology—that is, the academic departments and degree granting institutes associated with the discipline—has, will, or can go post-disciplinary based on institutional reform alone (2000, 2001). Furthermore, following systems science, there really is no need. People have to get bachelors and doctorates in something; besides, most of the push in the Academy (particularly in the United States) is toward market-based (not interdisciplinary) degrees anyway; and universities and college need a useful division of institutional labor to function.

Still, the European academy has been slightly more flexible in its institutional arrangements. As Abbott explains (2000), unlike the social science academy in the United States, where departmental boundaries are more rigid, the European academic system is better at structurally facilitating post-disciplinary arrangements through institutional reform within the social sciences, based primarily on some shared intellectual focus—such as the study of complex systems. This is due, in part, to a less entrenched disciplinary system, a more direct relationship between the social sciences and governmental agencies, a higher number of sociologists involved in free-standing institutes and centers, the development of international societies, and much stronger governmental funding, including growing support from the European Union (Abbott 2000, pp. 297–298). This difference in structural arrangements between the United States and Europe has been to the benefit of the BBC.

In terms of departments and centers, scholars in the BBC are creating, developing or participating in an incredibly successful network of programs, research groups, departments, all oriented and based upon a similar theme: complexity science. If one were to map this network of institutional arrangements and then overlay it on a map of the UK, one would have a topographical picture of the BBC. These institutional arrangements include the following:

- *The Innovations in Research Methodologies* group of the School of Applied Social Sciences at Durham University.
- *Center for Research in Social Simulation* (CRESS) Department of Sociology, University of Surrey, which is linked to a multitude of research projects, grants, business-academic liaisons, etc (cress.soc.surrey.ac.uk/)
- *The European Social Simulation Association* (www.essa.eu.org).
- *European Complex Systems Society* (www.cssociety.org).
- The European Commission's *Complex Systems Network of Excellence* (EXYSTENCE).
- *Centre for Mobilities Research* and *Centre for Science Studies*, Department of Sociology, Lancaster University (www.lancs.ac.uk/fass/sociology).

- *Lancaster Complexity Network*, Institute for Advances Studies, Lancaster University (www.lancs.ac.uk/ias/researchgroups/complexity/complexity.htm).
- *The Centre for Complexity Research*, University of Liverpool and Lancaster University.

6.2.2 Complexity Science and Sociological Methods

The second major goal of the BBC is methodological advancement. By now, the reader should know the following mantra well: from the topics it studies to the data it collects, the work of sociology has grown increasingly complex. Sociologists therefore need new methodological techniques and tools, primarily those coming from the science of complexity: agent-based modeling, data mining, computational statistics, dynamical systems theory, discrete mathematics, the new science of networks, and so forth. Without these methodological advances, organized sociology will become increasingly outdated or even obsolete.

Perhaps the most outspoken scholar in the BBC advocating for methodological overhaul is Nigel Gilbert, whom we discussed in our earlier review of computational sociology. He is not, however, the only one calling for reform. Another major scholar, who we have yet to discuss in much depth, is David Byrne.

Professor at the School of Applied Social Sciences, Durham University, Byrne is a leading sociologist in the UK and former editor of one of its flagstaff journals, *Sociology*. Byrne is also a methodologist, and a very thoughtful and creative one at that. His articles and books are well crafted, well written, intelligent and subtle. He does not make grand statements. He makes important provocations. One of his important provocations, written about in a series of articles with titles such as "Platonic Forehand versus Aristotelian Smash" (2002) and "Complexity, Configurations and Cases" (2005) is that, while complexity science is great, sociologists need to think carefully about how to employ, develop and even ignore its various techniques and tools. There are too many epistemological, conceptual and theoretical issues at stake. One example: the danger of losing the sophistication of sociological explanation to the simplicity of simulation.

As we discussed in our method chapter, complexity scientists tend to treat social systems as the outgrowth of simple processes (Byrne 2001, 2002; Cilliers 1998; Macy and Willer 2002). Byrne calls this perspective *simplistic complexity* (2005). Richardson and Cilliers (two important scholars affiliated with the BBC) refer to it as *reductionistic complexity* *science* (2001). The basic view of the simplistic/reductionistic perspective, which is practiced by such powerful and important thinkers as Holland (1998) and Wolfram (2002), is that a system's complexity (regardless of the system) emerges out of a very basic set of rules carried out by a large network of agents (mathematical numbers, biological cells, plants, ants, fish, etc) over a defined period of time. Amazingly enough—and Byrne (2005) as well as Richardson and Cilliers (2001) agree with this point—reductionistic complexity scientist has been quite successful at modeling various types of social systems, specifically those at a smaller (meso) scale. From the study of traffic patterns to the group-level transmission of cultural values to the competition of businesses, scholars using a reductionistic approach have demonstrated that social systems can be initially understood rather well through the agent-based iteration of a basic set of discrete rules (Axelrod 1997; Halpin 1999; Macy and Willer 2002; Watts 2004).

Still, as Byrne (2001) and others point out, this initial understanding is not the same as explanation (Gilbert and Troitzsch 2005; Goldspink 2000, 2002; Klüver, Müller, Malsch and Schulz-Schaeffer 1998; Strübing 1998). There is still a significant amount of theoretical and epistemological slippage that happens when moving from the articulation of a few rules upon which some social system is based to actually explaining how this social system emerges. Agar discusses this "slippage" in detail in *My Kingdom for a Function* (JASSS, 6, 3, 2003). While advocating the usage of computer simulation, Agar recognizes that the concepts he developed through this qualitative research did not transfer easily to the rule-oriented thinking of the computer. There was much slippage, begging Agar to ask, rhetorically, did I give up my empirical kingdom (his qualitative work) for a function (a set of computer algorithms)?

To remedy this problem, Byrne suggests that for sociology a new approach to complexity science methods needs be developed, one that he refers to as *complex complexity*, or what we will call C^2. We turn now to a review of this perspective.

6.2.3 C^2

The desire to embrace and yet develop the tools and techniques of complexity science through their rigorous integration with the methods and theories of sociology has resulted in the development of a major subcluster of research in BBC, which we call, after Byrne, *complex complexity* (C^2). The goal of C^2 is twofold: (1) use the critical lens of sociology (specifically the sociology of science) to examine the claims of complexity science method and (2) explore, critique and advance the epistemological, theoretical and methodological rigor of complexity science methods by integrating them with existing sociological theories, methods and techniques.

The reader may wonder how C^2 differs from computational sociology. The answer to this query is that C^2 is a subset of computational sociology, based on the particular epistemological, theoretical and methodological viewpoints of the BBC.

As a side note, not all of the scholars in BBC are British. Cilliers and Goldspink are Australian and Troitzsch is German. Goldspink, however, recently took a position at Gilbert's *Center for Research in Social Simulation* (CRESS), University of Surrey. Regardless of their academic affiliation, we refer to all of these scholars as part of BBC because they are involved in the creation and development of its common intellectual concerns and identity, including involvement in its publications, conferences, journals, centers, think tanks, and academic networks.

Getting back to the parallels between C^2 and computational sociology, one might also think of C^2 as the epistemological branch of computational sociology. While much of computational sociology focuses on developing and employing the tools of simulation, data mining, and so forth, C^2 takes a step back to consider the legitimacy of these methods for sociological inquiry. One example of this focus is the 2005 issue of JASSS (Volume 8, number 4) which was devoted to the epistemological status of simulation for social science inquiry. Organized by Frank and Troitzsch, this issue came from a series of papers delivered at a "workshop on 'Epistemological Perspectives on Simulation' in July 2004 at the University of Koblenz, in which some thirty colleagues participated" (See jasss.soc.surrey.ac.uk/8/4/7.html. Accessed 31 January 2008). The questions these scholars addressed ranged from "What kind of research questions can be addressed by simulation?" to "How does a simulation model relate to reality?" to "What kind of real world decisions can be supported by simulation?"

While the answers provided by these scholars are a discussion for another time, their combined insights are relevant to our current point. If sociologists are going to ultimately embrace and develop the tools of complexity science to the advantage of sociological inquiry—and, hence, society—the seriously hard and tedious work of carefully integrating them with sociological theories and methods will need to take place with the broader program of research in computational sociology.

6.2.4 Integrating Complexity Science and Sociological Topics

The third major goal of the BBC is to make the "complex system" its primary theoretical framework. Theory is a major goal of the BBC. To date, other than Luhmann, the BBC is the only area of sociology to offer a new and somewhat complete theory of social complexity. Examples include Byrne's *Complexity Theory and the Social Sciences* (1998) and Urry's *Mobilities* (2007) and *Global Complexity* (2003).

As a related goal, the BBC also seeks to use the complex systems framework as the basis for exploring any and all sociological topics. These topics range from globalization to urban planning to social mobility to gender and inequality.

Reviewing the sociological topics of BBC also is to review its current and developing network of scholars. While our review of the BBC here has focused on a small handful of scholars, with particular emphasis on the work of Byrne, Urry and Gilbert, there is a rather extensive network of scholars involved in the BBC. The work of these scholars is quite broad: economics, psychology, geography, medicine, political science. This work also has extensive links to complexity science, particularly its development in Europe.

As a side note, the European Union has invested heavily in the development of a complexity science perspective throughout the sciences, government and the business community. This investment, to our knowledge, is unparalleled. It also is incredibly successful. Several BBC scholars have been pivotal to this enterprise, the most noteworthy being Nigel Gilbert—see (cssociety.org/tiki-index.php).

Returning to our discussion of topics, the last agenda of the BBC is to use the vast repertoire of complexity science concepts (self-organized criticality, bifurcation points, fractal scaling, attractor points, etc) to rethink or enhance sociological inquiry. An excellent example is John Urry's Center for Mobilities Research (CeMoRe) at Lancaster University, which houses over 15 residential and visiting scholars (www.lancs.ac.uk/fass/sociology/cemore/). Common to the work of these scholars is the idea that sociology must move beyond traditional nomenclature, particularly the concept of society as linked to the concept of nation-state and embrace a view of society as highly mobile and global.

6.2.5 Sociology Intellectual Traditions

The final goal of the BBC is to develop systems thinking by updating it with the latest advances in sociological theory and continental philosophy.

While the methods of complexity science have significantly advanced systems thinking, complexity scientists are not very sophisticated when it comes to sociological theory or post-positivistic epistemology. Remember our quote earlier from Watts: "Physicists may be marvelous technicians, but they are mediocre sociologists" (2004, p. 264). Complexity science needs theoretical and epistemological advancement.

The fourth goal of the BBC is to help complexity science make this advancement. Examples of theories and epistemologies the BBC draws upon to advance complexity science include: (1) Urry's (2003) extensive use of Castells; (2) Walby's (2007) integration of complexity science, sociological systems theory and the literature on inequality; (3) Cillier's (1998) integration of complexity theory with post-structuralism, specifically the work of Derrida; and (4) Byrne's (1998) development of a complexity science grounded in critical realism.

Conclusion

In spite of its accomplishments, the BBC is not yet a complete and coherent school of thought. Everything is still in flux, but it is quickly shaping up. The number of new scholars, articles, conferences, intellectual networks, websites and international links emerging (almost monthly) within the BBC is impressive. There is definitely a sense one gets from studying the BBC that some type of critical point where it transitions into something larger is looming. What that something is remains unclear. Our best guess is the merger of the BBC into what one might refer to as a broader European School of Complexity, with several branches of thought. The Complex Systems Society just released a "Who's Who in Complexity Science" registry. It would be very interesting to do a network analysis of this registry to see if such a European School of Complexity is emerging (cssociety.org/tiki-index.php). Whatever this transition turns out to be, the BBC will play a primary and major role in its development.

6.3 The Luhmann School of Complexity

The other major school of thought in SCAS is new social systems theory, or what we will alternatively call the Luhmann School of Complexity (LSC). We use this alternative name for two reasons.

First, we use it to distinguish LSC from the variety of systems theories that exist within sociology, systems science and complexity science (See

Bailey 1994; Hammond 2003; Klir 2001). For example, there is systems science in general, which is comprised of a variety of frameworks: (1) Bertalanffy's general systems theory, (2) Forrester's system dynamics, (3) Capra's ecologically-based systems theory; (4) Miller's living systems theory; (5) engineering-based systems theory, specifically the work of George Klir; (6) biological and developmental systems theory; and (7) control systems theory. From here one can go to the variety of systems perspectives in sociology and the social sciences (which have links to systems science as well). These social science perspectives include the early systems thinking of Pareto, Spencer, Marx and Durkheim. They also include, more recently, structural-functionalism and the work of Parsons, as well as the development of neo-functionalism, specifically the work of Jonathan Turner. System thinking also extends to other disciplines including family systems theory (psychology), economic systems theory and political systems theory. Getting back to sociology, there are also the more recent systems theories of Wallerstein, Castells and Urry (which we have mentioned); the social systems theory of Walter F. Buckley (which is used as the theoretical basis to sociocybernetics); and the new systems theory of Kenneth Bailey—another key scholar in sociocybernetics who, by the way, is a professor of sociology at UCLA where he is a colleague of Bonacich, one of the leaders in the new science of networks. Finally (and our list is by no means complete), there are the systems theories of complexity science, some of which we have reviewed in detail in Chap. 5: Holland's emergent theory, Prigogine's dissipative structures theory, Maturana and Varela's autopoietic theory, Kauffman's evolutionary theory, and so forth.

While the Luhmann School of Complexity (LSC) borrows from and makes important contributions to these various systems traditions, it truly is a unique perspective and should be treated as such. Furthermore, as Hammond points out (2003) of the various systems perspectives within the social sciences (and specifically sociology), LSC is the most dominant. Its distinct character therefore needs to be highlighted (For an interesting network visualization of Luhmann and his links with systems theory, see www.systems-thinking.de/.)

The second reason we use the term LSC is because, since Luhmann's death his ideas have been developed further by a world-wide list of scholars in the social sciences and the humanities. This posthumous work—which would take a book to review—has turned Luhmann's ideas from one scholar's view of the social world into a new school of thinking. For example, an author search on the *Web of Science Social Science and Humanities Citation Index* gets almost 3,000 hits for "N. Luhmann." Some of the more well-known leading scholars involved in the LSC movement include (1) Hans-George Moeller (who has written one of the best English-speaking overviews of Luhmann's work); (2) Eva Knodt (one of

Luhmann's best German-to-English translators); (3) Stephan Fuchs (one of Luhmann's students and now a leading advocate); (4) Gunther Teubner (a major international figure in the Luhmann school of thought and Professor of Private Law and Legal Sociology, University of Frankfurt and Centennial Professor, London School of Economics); (5) Dirk Baecker (a more recent contributor to the LSC and a member of the Department for Communication and Cultural Management, Zeppelin University); and, finally, (6) Loet Leydesdorff (a major figure in the LSC and Senior Lecturer, Department of Communication Studies, University of Amsterdam). For a more complete overview of Luhmann's legacy, see Moeller's *Luhmann Explained: From Souls to Systems* (2006).

6.3.1 The Luhmann School of Complexity Profile

To gain a better understanding of the LSC, we will review its *web of social practices* profile. However, we will do so by way of a comparison to the BBC in hopes that this contrast will help to articulate what makes these two schools similar and yet unique.

Complexity Science Lineage: Like the BBC, the LSC is resolutely post-disciplinary, situating itself comfortably within the systems science tradition. Furthermore, like Urry, the goal is to go mobile, but not to dissolve the boundaries of sociology.

Consider, for example, Luhmann. Not only did Luhmann arrive late to the discipline of sociology, he never fully fit in. He was always more a systems science scholar than a sociologist; and his work always spilled over into other disciplines and areas of study. In fact, Luhmann is the embodiment of Urry's *creative marginality* because his work drew upon and added to such diverse areas as biology, philosophy, mathematics, history, historiography, literature, and law—the last being Luhmann's first academic background and professional life. As Arnoldi points out, Luhmann liked sociology because is did not "restrict" him academically (2001, p. 12). The fact that Luhmann is now seen as giving sociology a distinct character through his new social systems theory, "would probably please him" (Arnoldi, 2001, p. 12)

Another example is the academic diversity of the rest of the scholars involved in the LSC. Case in point: if one examines the 61 publications by Luhmann listed on the *Web of Science Social Sciences and Humanities Citation Index*, the following is revealed. Only 40% of those citing Luhmann are in sociology (N=224). The remaining (60%) come from disciplines as broad as literary studies, law, management, philosophy, geography and communications studies. The disciplinary diversity of scholars in the LSC is further corroborated by the tremendous variety of journals in which these 224 citations are published. Examples of the over hundred different journals include: *Zeitschrift Fur Padagogik*, *Cambridge Journal of Economics*, *and Journal of Law and Society*.

Sociological Lineage: Despite the intellectual diversity of the LSC, it is (ironically) the most traditionally sociological area in SACS. More specifically, it has the most direct ties to the systems tradition in sociology, including Luhmann's direct work with Parsons.

Sociological systems thinking is not, however, the only lineage within sociology upon which the LSC draws. The LSC is also very much grounded in German sociology, running from Marx and Weber to Habermas and the Frankfurt School to phenomology and the work of Schutz. In fact, part of Luhmann's fame comes from his notorious and often heated debates with Habermas over the utility of critique, reason, Enlightenment ideals, systems thinking and, most important, communication (Leydesdorff 1996). Luhmann's students and followers have continued this debate (e.g., Moeller 2006).

Complexity Science and Sociological Method: Unlike the BBC, the LSC has little to do with agent-based modeling. A basic search on JASSS, for example, gets a couple of hits where an author uses simulation to test some of Luhmann's ideas. The German sociologist and computational modeling expert, Klüver, for example, has made use of Luhmann (2000). There is even a nod to Luhmann in the work of socionics, which has a strong footing in German sociology (Fischer, Florian and Malsch 2005). Beyond this, however, the dominant methods used in the LSC are historical or literary. By literary we mean the methods of the humanities: argument, essay, textual analysis and the study of discourse.

Complexity Science and Sociology Topics: Two topics dominate Luhmann's work: autopoiesis and society. Society is the sociological topic he wants to elucidate and autopoiesis is the complexity science topic he uses to make this elucidation happen. To better understand these twin concepts and the role they play in his work, we need to review Luhmann's theory. While the LSC has been developing Luhmann's ideas for the past decade, including revision, critique and application, Luhmann's original work remains central to this school of thought. Furthermore, at least to our knowledge, no revised neo-Luhmann theory has been written. As such, to understand Luhmann is to understand the LSC. We therefore turn to a review of Luhmann.

6.3.2 *Niklas Luhmann: A Basic Review*

The most famous systems scientist in sociology is the creator of structural-functionalism, Talcott Parsons (1902–1979) (Bailey 1994; Luhmann 1989, 1995; Turner 2001). Not only did Parsons conceptualize society and its constituent parts as a system, but he did so using the terminology of 1950s cybernetics and systems science: adaptation, feedback, system evolution, goal attainment, and equilibrium (Collins 1988). As Parsons began to fall from theoretical favor during the 1970s and 1980s (replaced, in part by conflict theory and Marxism), so too did systems theory. Even the neo-functionalist Jeffrey Alexander concedes this point (Ritzer and Goodman 2004, p. 226). What most sociologists, particularly those in the English-speaking world, do not realize, however, is that while functionalism remains theoretically marginalized, sociological systems theory is alive and thriving (primarily in Europe) in large measure due to the work of Niklas Luhmann (1989, 1995).

Over the last thirty years of his life, Niklas Luhmann (1927–1998) developed one of the most extensive theories of modern society and its constituent parts. He called this theory *system theory* (1995). As Bailey (1994) and others explain (Arnoldi 2001; Turner 2001), system theory sits at the intersection of three fields of inquiry; complexity science, radical constructionism and sociology (specifically the work of Parsons). Drawing upon these three traditions, Luhmann argues that the purpose of sociology is to provide modern society with a way to communicate with itself. This is why, for example, Luhmann titled his magnum opus, *The Society of Society* (See Mingers 2002). For Luhmann, sociology is part of society. It is one of a variety of functionally differentiated subsystems within society—a discipline within the larger subsystem of academia and science that exists to provide society a discourse about itself. In this way, then, when sociology speaks, society is speaking (communicating) with itself.

For Luhmann, society is the most important topic in sociology because, without a fundamental theory of society sociology lacks a proper understanding of itself. This thesis is central to Luhmann's oeuvre. To understand it more fully we need to review his concept of autopoiesis.

6.3.2.1 Social Autopoiesis

Despite the breadth of his theoretical approach to the study of society, any review of Luhmann has to begin and end with his second most important concept, autopoiesis. Luhmann's usage of autopoiesis, which literally means self-producing, is taken from the work of Humberto Maturana and Francisco Varela (1980, 1998). Both theoretical biologists and complexity scientists, Maturana and Varela created the term to provide a *materialist* explanation for the difference between living and nonliving systems. What makes a living system unique for Maturana and Varela is not so much its composite parts and structure, but rather the organizational form it takes. In their own words, "Living beings are characterized by their autopoietic organization. They differ from each other in their structure, but they are alike in their organization" (1992, p. 47). Luhmann, in turn, transported the work of Maturana and Varela to the field of sociology, and created a new term, *social autopoiesis*, which he applies to the study of society.

Framed within the concept of social autopoiesis, Luhmann argues that society is best conceptualized as a self-producing, complex, emergent, self-organizing, self-steering, structurally open-ended, organizationally closed, dynamic, adaptive, evolving, autonomous system of communication. We will break this argument down into a series of points to make it clear.

1. Society is a complex system of communication. For Luhmann, what distinguishes society from all other systems—be they physical, technological, psychological—is that it is entirely symbolic (1989). Society is a complex network of discourses, which, through their interactions, self-organize to form an emergent system of communication.

2. Society, as a system of communication is not agent-based. Like the French structuralists (Claude Lévi-Strauss) and early post-structuralists (Michel Foucault), Luhmann is an anti-humanist (Moeller 2006). While humans are obviously connected to society, society does not ride on the backs of individual communication—otherwise known as symbolic interaction. Instead, society, as a system of communication, is an emergent phenomenon, taking place above and beyond the agents of which it is comprised. Once society emerges, its patterns of communication have nothing to do with humans. Society is like a dumb communication machine, with little need of human supervision or guidance. Said another way, and in stark contrast to the dominant view of complexity scientists, society is not created from the ground-up. Luhmann states it this way, "Whether the unity of an element should be explained as emergence 'from below' or as constitution 'from above' seems to be a matter of theoretical dispute. We opt decisively for the latter" (1995, p. 22). Society is comprised not of individuals but of communication relationships. From this vantage-point, society is a complex system of communication.

Luhmann's conceptualization of society as communication does not mean, however, that society and human beings are independent, or that society is not structurally reliant upon the communicative acts of humans. Society obviously is a human affair. It is just that (contra Habermas) once society emerges through the symbolic interactions of human beings, it is no longer *organizationally* dependent upon these human agents.

3. Still, while society is not organizationally dependent upon humans, people are not so lucky. According to Luhmann, humans are enveloped within society so fully that society constitutes their inescapable horizon of thought. Here Luhmann is drawing upon Heidegger, Hegel and phenomenology. Because communication is central to human knowing, all human thought is immured within a particular societal pattern of communication (Luhmann 1989, 1995). This is true of the academic construction of knowledge as well. From sociology to physics, all of the sciences are patterns of communication within the larger societal system of which they form a functional part. Every human form of knowing is part of society because everything human is a socially constructed from societal communication.

4. The idea that all knowledge is housed within the communication patterns of society leads to one of Luhmann's big insights: society cannot have perfect communication about itself or anything else because it cannot get outside its own communication, primarily because society constitutes the whole of human communication.

5. Because society is a system of communication, it is not geographically bounded (Bechmann and Stehr 2002). In direct contrast to the majority of sociological thinking, Luhmann does not believe that society is a physically situated aggregate of human interactions—such as a nation-state. Instead, it is a process, a perpetual system of communication. This does not mean, however, that society has no boundaries. But, what defines these boundaries is not geography. Instead, its boundaries have to do with communication, which leads to our next point

6. Society, as an autopoietic system, is bounded by its relations of communication. In other words, society is an organizationally closed system through its relations of communication, (Mingers 2002). Anything outside communication per se, or about which communication is engaged, is society's environment. It is for this reason that Luhmann describes society as being autonomous. Consider communication within a group of people. Whatever (or whomever) is not part that group's communication network is treated as someone on the outside. Even an individual member of this group, if she or he is ex-communicated (note the term communication within this act), becomes someone outside the group.

7. As an organizationally closed system, the goal of society is self-production (Luhmann 1995). Put simply, following Durkheim, Spencer, Parsons and the structural-functionalists, society exists to perpetuate itself.

8. While society is autopoietic, it is not alive (Luhmann 1989, 1995). For Luhmann, because society is a system of communication that is independent of human agency, it cannot be alive. Instead, it is more like a dumb machine.

9. One of the most important challenges to modern society is complexity (King and Thornhill 2003; Luhmann 1989). In concert with the majority of complexity scientists, and with scholars working in SACS and the field of globalization, Luhmann argues that society is becoming increasingly complex, as a global system of communication (Geyer and Zouwen 2001).

10. As an autopoietic system, society addresses its growing complexity by differentiating into a network of emergent subsystems (Luhmann 1982). Examples of these subsystems include the various social institutions associated with modern society: science, marriage, family, health care, education, economics, politics, law, culture, art, etc. (See Moeller 2006).

The autopoietic function of each subsystem is to communicate with society about a particular issue of complexity. In other words, when society finds itself unable to handle its internal or external complexity, often due to some type of challenge (be it an issue of health care, epidemic, ecological crisis, economic inequality or political conflict) a subsystem will emerge and do so by establishing for itself an open-ended boundary between itself (as a subsystem of communication) and the particular issue of complexity it was created to address. This issue of complexity, in turn, becomes this subsystem's environment. In other words, the complexity of a system, while internal to itself, often leads to the emergence of a subsystem which treats this internal complexity as its environment, about which it communicates to itself and others as external to itself. For example, the discipline of sociology is a subsystem of society, which treats society—the system in which sociology is situated—as the environment about which sociology communicates, as if society were external to the discipline, even through sociology is situated within society.

The key here, is that a subsystem's environment is not really separate from the system's communication about it (Luhmann 1989, 1995). In this way, the environment is not a thing. Neither is it an external object of subjective knowing. Instead, the environment is a series of "internal constructions" created through a subsystem's relations of communication. In other words, the environment is a linguistic (i.e. social) construction created internally by a subsystem to deal with (adapt to) some particular complexity of life—which finally brings us back to the reason why the concept of society is so important to Luhmann's sociology.

As we discussed at the beginning of this section, Luhmann believes that modern society is going through a period of major transformation. To address this transformation, as the early scholars of sociology once did, Luhmann argues that sociology needs to get back to its primary task: creating theories of society that help society communicate with itself. From this perspective, if Luhmann were alive he would embrace the mobile sociology of Urry, and Castell's global network society, because they are attempts to rethink society in terms of what society is communicating to sociology about itself. Put simply: sociology is the primary communicator to society about what society itself is communicating regarding its evolving challenges. Without such proper communication, sociology is useless—and society is partially silent.

6.3.3 The LSC Today

While Luhmann passed away in 1998, as we mentioned earlier, other scholars are advancing the work of the LSC. These scholars include Klüver (2000, 2002) Mingers (2002), Moeller (2006) and Turner (2001).

One key question for these LSC scholars is the extent to which society and its various subsystems, including complex human organizations, meet Luhmann's definition of social autopoiesis. As stated earlier, Maturana and Varela created their term to distinguish living from non-living systems. How, then, can a nonliving, relatively dumb system of communication, such as society, engage in the processes of self-production and self-preservation? These are issues that Luhmann's work, despite all of its brilliance, did not resolve.

A second question of great interest to LSC scholars is the extent to which society is truly free of human agency. Luhmann has been scathingly critiqued for his complete dismissal of human agency (Mingers 2002). After Parsons and the criticisms leveled against him for the absence of people in his work, along with the massive movement toward agency-based theories in sociology during the 1980s and 1990s, it is hard for scholars, even within the LSC, to grasp Luhmann's theoretical avoidance of agency. This issue is therefore of primary importance within the LSC, and for scholars outside this area of research.

Nevertheless, regardless of how one addresses the above two questions, one must recognize that the LSC constitutes a formidable theory of society which, agree with it or not, must be reckoned with. It is the power of Luhmann's work that makes the LSC a major player in SACS, complexity science, the tradition of systems thinking and sociology.

6.4 Sociocybernetics

The final research community is sociocybernetics. It has the following *web of social practices* profile.

6.4.1 Complexity Science Lineage

The connection of sociocybernetics to the cybernetics lineage is more pronounced and direct than any other area in SACS. For example, while the LSC is connected to cybernetics through the work of Maturana and Varela, and while CSNA, the BBC and computational sociology draw upon cybernetic methods, none can claim to be a branch of the cybernetics tree. Sociocybernetics can. In fact, it is a direct descendant and major branch of cybernetics—see Map 1. Furthermore, several key scholars in sociocybernetics are major figures in the cybernetics tradition, namely Walter Buckley, Kenneth Bailey, and Felix Geyer.

As Geyer and Zouwen explain (2001), sociocybernetics emerged out of the growing interest of system scientists in the application of cybernetic principles to the study of social systems. The classic example of this growing interest is Norbert Weiner's *The Human Use of Human Beings: Cybernetics and Society* (1950/1954). The reader may recall that earlier in this chapter we defined socionics, in part, as the study of how human systems are becoming more like computer systems through the human/computer interface. We also defined socionics as the control of computer systems through the study of how they act like human systems. These are the same goals of cybernetics, as envisioned by Wiener, with a major twist. To make sense of this twist, and how it led to the development of sociocybernetics, we take a brief historical detour into the work of Wiener.

6.4.1.1 The Development and Limitations of Cybernetics

It is important to remember that, when Wiener invented cybernetics, it was the early 1950s. In mathematics, this was the beginning of the computer age and, in the United States, it was the beginning of the cold war. A brave new world was emerging comprised of new communication systems, war games, missile guidance systems, computer databases, game theory. And (going into the 1960s) concerns with governmental control over society were a major intellectual and political issue. (As a side note, Wiener was a liberal and opposed to military usage of his ideas—see Hammond 2003.)

The 1950s was also the heyday of American sociology, including Talcott Parsons and the Department of Social Relations at Harvard; C. Wright Mills' *Power Elite* (1956); and David Riesman's *The Lonely Crowd* (1950), which sold over 1.3 million copies.

Most important for the current story, the 1950s was the beginning of the merger between computer science and social science (remember the methodological lineage of computational sociology we reviewed earlier), creating a new vision and understanding of how humans and their human societies worked. Wiener was one of the scholars at the forefront of this merger.

Wiener's argument in the *Human Use of Human Beings* is twofold. First, he believed that the human/computer interface was creating an entirely new world, for which science needed to help society prepare. The second argument, however, is what got Wiener into trouble. He believed, based on the first argument that the best way to gain control over contemporary human society was to understand how it acted like a computer system. More specifically, how society acted like a machine-based communication system. Of the various arguments made by cybernetics, this one pushed sociologists and social scientists away from this field (Capra 1996). It is one thing to claim that the computer/human interface is creating a new society (which we refer to today as post-industrial, postmodern, global network society). It is quite another, however, to argue that human society is best understood through the framework of communication networks.

Once again, we need to contextualize Wiener's argument. When cybernetics first emerged, it was a major hit in the natural sciences and engineering. Transferring the success of cybernetics to the social sciences made sense. If society is becoming a massive communication system, then understanding it through the framework of cybernetics seemed best. It was quite reasonable for Wiener, being a mathematical genius and innovator in the control of communication systems (feedback, control theory, chaos and noise in systems, Shannon's information theory, etc), to move his theory to the study of society. (As another aside, let us not forget that even Luhmann defines society as a communication system.) The computer was the perfect metaphor for understanding human systems.

Wiener, however, was wrong. He was wrong for two reasons. First, unlike machines, human systems are reflexive. They can react and adapt to the scientist's knowledge of them. Second, scientists do not exist outside the human systems they study.

These two realizations of the limits of cybernetics for studying society led Wiener and his colleagues to create a new version of cybernetics, which Heinz von Foerster called *second-order cybernetics*: the study of control and communication in human, particularly social systems.

6.4.1.2 Second-Order Cybernetics

Second-order cybernetics is important to the development of sociocybernetics for two reasons. The first is its emphasis on *self-observation within systems*. Second-order cybernetics recognizes that social systems are meaning making, communicating, self-reflexive, self-regulating and self-producing phenomena. This is why Foerster defines second-order cybernetics as the "cybernetics of observing systems" (See Capra 1996). Nonliving systems such as a computer, welding machine, internet, or cell phone are not self-observing. They do not possess—at least not yet—the capacity for self-reflection. At best, they are forms of artificial intelligence. Information comes in, it is processed, and a certain set of actions take place. Social systems, in contrast, are self-observing. They have the capacity to reflect on themselves and therefore change their behavior, both in relation to themselves and those observing them.

The second reason why second-order cybernetics is important to the development of sociocybernetics is because it addresses the problem of *observing self-observing systems*; or what is referred to in sociology as the "sociology of knowledge" problem. This problem, which most sociologists are well versed in, focuses on many of the arguments raised by the linguistic turn in philosophy, sociology, and the humanities (post-structuralism, postmodernism, feminism, multiculturalism, and neo-pragmatism). How are we able to understand society if we are situated within it? Can sociologists do naturalistic inquiry? Even more important, pace Luhmann, how does society come to know itself?

6.4.1.3 Sociocybernetics is 3rd Order Cybernetics

While the above two reasons were important to the development of sociocybernetics, they were insufficient. At the end of the day, even second-order cybernetics did not seem to the early scholars of sociocybernetics as sufficient for the study of social systems (Geyer and Zouwen 2001). The whole project of cybernetics needed to be pushed further.

Said another way, the scholars of sociocybernetics were not content with the one-way transfer of second-order cybernetics to the study of sociology. Instead, they believed a two-way relationship needed to be established where sociology and second-order cybernetics critically intersected to create a new approach to the study of social systems. Hence a new area of research within SACS emerged.

6.4.1.4 The Argument of Sociocybernetics

If the argument of sociocybernetics sounds familiar, it should. This is the same argument we have discussed in this book regarding complexity science and its integration with sociology. The only difference is that sociocybernetics made this argument over 40 years ago.

The first sociologist to make the argument of sociocybernetics was the American sociologist, Walter F. Buckley, professor of sociology at the University of New Hampshire and 1998 honorary chair of the sociocybernetics research committee (RC-51) of the International Sociological Association.

In a series of books and articles, most notably his 1967 publication *Sociology and Modern Systems Theory*, Buckley argued that the sociological theory of systems needs to be rewritten. The action-based, functionalist theories of Parsons, along with the equilibrium and evolutionary models of Durkheim and Spencer, needed to be thrown out and replaced with the latest advances taking place in second-order cybernetics. Equally important, second-order cybernetics needed to be integrated with the ideas of sociology.

The result, for Buckley, was the realization that social systems are complex, open-ended, dynamic, self-organizing emergent phenomena. Furthermore, social systems operate in a position between chaos and order, adapting to internal and external pressures through the twin forces of morphostasis and morphogenesis. The last two terms Buckley created to provide his own version of social autopoiesis: the dynamics by which a system reproduces itself while adapting to internal and external pressures to change.

6.4.1.5 Too Much Too Early

The sociological reception of Buckley's ideas is a story of too much and too early. While second-order cybernetics and systems science immediately got the point, sociology (in a manner reminiscent of its whole-scale rejection of all-things systems) seemed to miss the boat.

For example, the review of Buckley's 1967 book in the *American Sociological Review* was by the famous systems scientist, Anatol Rapoport, not a sociologist. Rapoport understood what sociologist did not: Buckley's ideas were far ahead of his time. The result was that Buckley's ideas were not significantly embraced. Even though he leveled a thoroughgoing critique against Parsons and created a new theory of social systems, the zeitgeist in sociology was moving away from systems thinking. Fortunately, his work did not go entirely unused. Likeminded sociologists in the 1970s and 1980s picked up his ideas to create what they saw as a new field of study, which they began to call sociocybernetics.

6.4.1.6 The Formal Emergence of Sociocybernetics

While Buckley was instrumental in pioneering the idea, sociocybernetics, as a legitimate area of research, was the brainchild of a small network of scholars working at the intersection of sociology and cybernetics. These scholars include Francisco Parra-Luna, Felix Geyer, Richard Henshel, Kenneth Bailey and Johannes van der Zouwen.

Parra-Luna was the primary originator of this area, working almost single-handedly to gain sociocybernetics status as a research group in the International Sociological Association in 1980. Over the next two decades, however, sociocybernetics had difficulty coalescing into a meaningful area of study. Finally, by 1999 sociocybernetics became a research committee (RC-51) in the *International Sociological Association*. During this time, it also established its own journal (*Journal of Sociocybernetics*), created a governing Board, developed its membership, began amassing a growing network of several hundred publications and put together a website (www.unizar.es/sociocybernetics/).

By the late 1980's, Parra-Luna was not alone in his efforts. He had much help. One of his most important helpers is Felix Geyer, Professor of Sociology, University of Amsterdam. While Geyer has not written a system theory of society nor created any major methodology, like Barry Wellman in complex social network analysis and like Nigel Gilbert in BBC and computational sociology, he is an authority. He has written most of the reviews on sociocybernetics, worked diligently to keep the RC-51 running, published book chapters and articles on various issues in sociocybernetics, founded the *Dutch Society for Systems Research*, co-edited with Zouwen the most updated book on the field (2001), and steadily sung the praises of this area of research to cybernetics and sociology. He has been recognized for these efforts. In addition to his status within the International Sociological Association, he is part of the "Who's Who" list of the American Society for Cybernetics and, equally important, the membership of RC-51 had swelled to over 240 scholars, boasting a network of scholars from across the social and natural sciences.

The eclectic nature of sociocybernetics's historical development is another feature it shares with the intellectual lineage of complexity science. Like complexity science, sociocybernetics is organizationally and intellectually post-disciplinary. In fact, sociocybernetics is so post-disciplinary that, if it were not for its status as a research committee in the *International Sociological Association*, one would be hard-pressed to even recognize the field. The reason, following the logic of creative marginality, is that most of its scholars claim primary identity in other areas, with their sociocybernetics affiliation being secondary. For example, just within SACS alone, members of sociocybernetics range from Jürgen Klüver (computational sociology) to John Mingers (LSC) to Immanuel Wallerstein (global network society). Despite the post-disciplinary nature of sociocybernetics, when it comes to the traditions of sociology, its focus is clear.

6.4.2 Sociology Lineage

Minor variations in theoretical usage aside, the sociological lineage to which sociocybernetics is linked is sociological systems thinking, including the ideas of the canonical scholars: Spencer, Marx, Weber, Pareto, and Durkheim. As we discussed earlier, however, sociocybernetics seriously sidesteps the structural-functionalist stage of systems thinking, avoiding altogether the work of Parsons. Instead, sociocybernetics turned its attention to Buckley and then Luhmann. These two scholars are the dominant theoretical frameworks in sociocybernetics (Geyer and Zouwen 2001).

6.4.3 Complexity Science and Sociology Method

It is important to remember that, like the LSC, sociocybernetics got its start way before the emergence of complexity science. As such, its methodological lineage reads somewhat like the history of computational sociology, starting with an early interest in equation-based modeling, artificial intelligence and control theory, turning to cellular automata and computational modeling, and eventually agent-based modeling. Unlike complexity science method, however, sociocybernetics is equally historical and qualitative in its methods, particularly when it comes to studying formal organizations and the various subsystems of society: economy, law, politics, etc (Geyer and Zouwen 2001).

6.4.4 Complexity Science and Sociological Topics

The last issue to address is the topics of sociocybernetics. Unlike the BBC or the LSC, which seek to revise key concepts in sociology such as society, the focus of sociocybernetics has consistently been on integrating sociology and second-order cybernetics. In fact, as Geyer and Zouwen have argued in a series of publications (1992, 2001), despite interest in a variety of empirical topics, the dominant topics in sociocybernetics all have to do with constructing a meticulous theory of social systems in light of second-order cybernetics and the challenge of studying social (self-observing) systems.

Here is a brief overview of these themes. Starting in the late 1970s and early 1980s, the theme was refuting Parsons and replacing his ideas with the latest advances in systems science and second-order cybernetics. The next major theme, appearing during the middle 1980s was examining the dynamics of social systems, conceptualized as systems in transition. The primary empirical focus for this work was developing countries, with a nod to world systems theory. In the late 1980s and early 1990s, the focus moved to the "paradoxes inherent in the observation, control and evolution of self-steering systems—specially the paradox important to policy-makers worldwide: how can one steer systems that are basically autopoietic and hence self-referential as well as self-steering" (Geyer and Zouwen 1992, p. 4)? By the late 1990s (and up to the present) the focus of sociocybernetics shifted to the newly emerging field of complexity science, focusing on the epistemological, methodological and theoretical challenges of studying complexity. In their 2001 edited book, *Sociocybernetics*, Geyer and Zouwen organized this theme into three subsections: growing societal complexity, autopoiesis, and observation of social systems.

Conclusion

While sociocybernetics might not enjoy the popularity of the new science of networks or computational sociology, and while it does not have the focus and following of the LSC or the BBC, it is an important area of research in SACS, primarily because its work is like therapy: while excited about the new ideas in cybernetics, systems science, agent-based modeling, artificial intelligence, complex networks and complexity science as a whole, the epistemological concerns sociocybernetics has with the difficulties of studying social systems reminds us to always proceed cautiously, making sure we are doing science and not the latest fad. With this said, we have completed our review of the areas of research in SACS.