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Organizational dynamics: Issues and implications from the complexity sciences

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ORGANIZATIONAL DYNAMICS: ISSUES AND IMPLICATIONS FROM THE COMPLEXITY SCIENCES

by

Kenneth Michael Mathews, BA, MBA

A Dissertation Presented in Partial Fulfillment
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Doctor of Business Administration

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ABSTRACT

Organizational change, both developmental and transformational, is an issue of central and enduring concern in the organizational sciences. However, the processes, mechanisms and sequencing of events that describe how and why social systems change have not been satisfactorily explicated at a theoretical level and constitutes one of the major challenges facing the social sciences. This research examines issues and implications from an emerging perspective – the complexity sciences – developed to explain the mechanisms and processes of change in physical and natural systems. The purpose is to develop a theoretical approach to the study of change in social organization that integrates these implications, while remaining grounded in current knowledge of organizational and social processes.

The complexity sciences are eminently suited to address this lack in the field. However, the implications accruing to the complexity sciences are little understood or appreciated by organizational researchers. For the complexity sciences to be of value to organizational scholars, the research imperative is for the development of a rigorous, internally consistent, and empirically adequate theory. The challenge facing organizational researchers is not to apply the complexity sciences to organizational phenomena. Rather, it is to develop a science of complexity and derive theories, principles and implications for organization science, knowing them for the natural sciences. Thus, the fundamental problem of integrating the complexity approach is for development at the philosophical and theoretical levels.

To that purpose, an analytic model of the processes and mechanisms of organizational dynamics is developed that: (1) derives from complexity science implications – the complex adaptive systems (CAS) approach in particular; (2) incorporates elements critical to an explanation of change phenomena – the driver, director, source, and modality of change; and (3) integrates these implications and issues at the theoretical and metatheoretical levels of analysis.

This research purpose is accomplished by comparing and contrasting assumptions and implications of the complexity sciences to those of "traditional" science. Critical issues in the development of an adequate theory of organizational dynamics are considered. Finally, a theoretical model of organizational dynamics is presented that integrates implications of the complexity approach into current perspectives on social and organizational change. The analytic model explicates the mechanisms and processes of organizational dynamics and provides theoretical guidance for subsequent empirical work on social and organizational change.

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INTRODUCTION TO PART I

"There is nothing permanent except change."
Heraclitus

"The study of the nature and processes of change, stability, transformation and transition is **the** *contemporary challenge <for organizational theorists>."*
Greenwood and Hinings (1987)

"The efforts <to understand complex systems> are so new that there is not yet even a generally accepted, comprehensive definition of complexity."
Stuart Kauffman (1991)

The purpose of this research project is to develop a theoretical approach to the explanation and understanding of the mechanisms of organizational dynamics that incorporates implications of the complexity sciences while remaining grounded in current knowledge of social processes. This statement of purpose contains four crucial elements.

First, the issue of how and why social organizations develop and transform over time (i.e., the dynamic behaviors of social systems) provides the substantive problem of interest. As is subsequently argued, an understanding of the processes and mechanisms by, and through, which organizations develop and transform is the most fundamental of all applied problems. The field of management is, to a large degree, predicated on either tacit and implicit assumptions or explicit statements of understanding and conceptualization of such processes and mechanisms. Unfortunately, these processes and mechanisms have not received an adequate theoretical treatment in the organizational literature.

Second, implications from an emerging approach to the study of change in physical and natural systems are explored as a perspective that offers new insights into the processes and mechanisms of social change. Collectively referred to as the complexity sciences, this approach draws from catastrophe theory, chaos theory, self-organized criticality, self-organization and dissipative structures and is finding expression in an integrative approach referred to as complex adaptive systems (CAS). The complexity sciences are founded on assumptions that differ, and take issue with, those of the dominant Newtonian/Darwinian foundations of contemporary social sciences. Because of these differences, the complexity approach offers an alternative theoretical lens through which the processes and mechanisms of system development and transformation can be viewed.

Third, the goal is not to develop a perspective or approach that breaks with or replaces current knowledge and understanding of the mechanisms and processes of social and organizational change. Rather, the purpose is to integrate the insights and implications deriving from the complexity sciences into contemporary approaches in organization theory. Though the abstract nature of the complexity sciences presents a major challenge to applications in organizational analysis, these insights are integrated into perspectives familiar to organizational researchers. Thus, the goal is not to break with the past and present, but to integrate these insights and implications with the goal of extending and enhancing the study of change, development and transformation in social systems.

Fourth, and finally, these insights, issues and implications must be integrated at the theoretical level before meaningful empirical efforts can proceed. Because of the fundamental and sometimes contradictory metatheoretical and paradigmatic foundations of the complexity science approach (as opposed to the Newtonian/Darwinian paradigm), an understanding and explication of these differences is crucial at this stage in efforts to apply the complexity approach to social processes. Management and managerial studies is an eminently applied discipline. However, the ways in which applied problems are conceptualized and the methodologies used to study those practical problems are inherently and inextricably (though often only implicitly) grounded in specific metatheoretical and theoretical assumptions and presuppositions. Alternate theories and metatheories may imply a need for a reconceptualization of applied problems and for the development of alternate methodologies for use in their study.

This is not to argue that current empirical efforts to apply complexity insights to social processes are either ineffectual or misguided. Both theory development and theory testing (and the methodologies that link the two) are ultimately necessary and complementary components of scientific progress. However, the premise of this effort is that new insights (especially when grounded in an alternate metatheory) must be developed at a conceptual and theoretical level in order to provide guidance and direction to subsequent empirical and applied efforts. In such cases, theory development is logically prior to theory testing. To that end, the development of an analytical model of organizational dynamics grounded in implications and insights from the complexity sciences – specifically with regard to the connectionist perspective of complex adaptive systems – is the principal objective of the project.

In pursuit of this purpose, several issues are addressed. Arguments are presented supporting the contention that an understanding of the processes and mechanisms of change phenomena are central to organizational theory, efforts to predict and control organizational behaviors, and that contemporary and traditional approaches have met with limited success. The critical issues involved in an understanding of organizational change phenomena are developed. Elements of the complexity approach are described and compared to contemporary and traditional approaches, particularly with regard to differences in fundamental assumptions and the implications derived from those differences at the level of metatheory. Insights and implications from the complexity approach are applied to two issues of concern in organizational theory: the metatheoretical problem of paradigm incommensurability and the theoretical problem of organizational change. The most basic contention made here is that the complexity sciences provide an integrating perspective that provide the linking mechanisms that allow for the inclusion of *both*

1) objective and subjective approaches to social phenomena and
2) internal and external (i.e., micro and macro) factors

in explanations of organizational development and transformation. The complexity sciences suggest that it is not a case of arguing that *either* one approach or factor is "true" or that *neither* is primary. Viewed from a complexity perspective *both* subjective and objective elements *and* internal and external factors are necessary to an adequate theoretical understanding of how and why social organizations change, develop and transform.

Though not a primary objective of the research effort, the methodological and empirical implications of the complexity sciences receive some attention. As secondary concerns, several themes underlie and thread throughout all of the chapters. These themes revolve around:

1) the methodological implications of the complexity perspective;
2) the implications of the complexity approach for the modeling of organizational phenomena and the link between theory and data; and,
3) the concern of whether or not the complexity perspective can be of more than metaphorical or analogical use to organizational researchers.

Though the use of metaphor and analogy can lead to useful insights, there is a danger that "...when the metaphor becomes the explanation...it can constrain the ability to see and interpret events" that the metaphor purports to explain (Johnson and Burton, 1994: 327). Implicit in the arguments presented in this research is the premise that the complexity sciences offer an approach to the understanding of the mechanisms and processes of social change that has more than metaphorical or analogical benefits. If this is the case, however, for the complexity sciences to be of real use to organizational researchers, "...a rigorous, internally consistent, and empirically adequate theory is the next required step" (Johnson and Burton, 1994: 328). This research is a step in that direction.

With this general objective in mind, the research is divided into three sections. The chapters in Part I discuss the research strategy, research questions and objectives, and introduces the complexity sciences. Chapter 1 discusses the research need, specifies the research objectives and questions, provides preliminary definitions, and develops the format and strategy for analysis. Chapter 2 addresses the limitations of traditional approaches to explanations of organizational change phenomena and develops the critical issues involved in the study of organizational developmental and transformational processes. The chapter also introduces the paradigmatic and metatheoretical issues underlying such explanations. Chapter 3 introduces the complexity sciences, offers additional justification for their application to the social sciences, and includes a literature review of recent applications of the complexity approach to organizational phenomena.

Part II is devoted to a development of current perspectives on systemic change processes and to a detailed examination of various approaches to complexity. Chapter 4 focuses on an historical development of perspectives on systemic change and illustrates the process of the "scientization" of social dynamics. Four assumptions are described that provide the foundation for "traditional" Newtonian/Darwinian science (and, by extension, traditional and contemporary organizational theory). These assumptions are discussed and their implications for the study of organizational dynamics are indicated. Chapter 5 contrasts the fundamental assumptions underlying the complexity sciences with the assumptions and implications of the Newtonian/Darwinian approach. This is accomplished through an analysis of five of the more distinctive approaches to the study of complex systems: the dissipative structures approach, catastrophe theory, chaos theory, self-organized criticality and Kauffman's self-organizing approach. These provide the foundations for the complex adaptive systems (CAS) approach.

Part III is devoted to extending the implications of the complexity approach to issues more directly relevant to organizational researchers. Chapter 6 applies the implications developed in Chapter Five to issues at the level of social metatheory. Burrell and Morgan's (1979) and Tsoukas' (1994) works are utilized as frameworks within which the arguments are developed. Chapter 7 extends, integrates and incorporates the complexity arguments at the level of substantive theory with the development of a theoretical approach to organizational change, transformation and development that views social systems as examples of complex adaptive systems. This chapter extends Turner's (1988) theory of dyadic interaction processes by integrating the insights of the complexity sciences and the development of an analytical model of organizational dynamic processes. The connectionist model developed and presented offers an integrative approach that links objective to subjective aspects of social organization and micro-level dyadic processes to macro-level system and environmental processes. A final chapter presents conclusions and suggestions for further research, including methodological implications of the approach.

Finally, we paraphrase Kauffman (1993: xvii) by noting that though this project is finished, it is not a finished project. The implications deriving from the complexity sciences are so fundamental and the potential for application so great that many years may be necessary for these issues to be integrated into mainstream organizational theory and analysis. Thus, much of the early work of integration must, of necessity, consist of a synthesis and review of existing work. As Rosser (1991: ix) notes, "...given the ongoing explosion of material in this area it is difficult to call a halt" to efforts examining the complexity sciences. With these considerations in mind, we present our current understanding of the complexity sciences and the issues and implications they raise for the study and analysis of social systems and human organization. We hope that this work serves to inspire others to a closer examination of these intriguing perspectives.

CHAPTER 1

RESEARCH PURPOSE, OBJECTIVES AND METHODS

The premises underlying this research effort are fourfold. *First*, an understanding of the processes and mechanisms of social change is the primary and fundamental contemporary problem for organizational theory and the managerial disciplines. *Second*, a complexity science perspective offers the potential for enhancing and extending the understanding of such processes and mechanisms and for overcoming the limitations of contemporary approaches. *Third*, the complexity sciences provide a basis for the resolution of several issues of contention and paradox in organizational theory. Grounded in assumptions that differ from, and provide an alternative to, the dominant Newtonian/Darwinian metatheory the complexity paradigm promises to allow for the integration of competing perspectives on organizational change phenomena. *Fourth*, such integrative efforts must focus on theory development before meaningful theory testing can occur.

This chapter serves to identify the research need and significance, specify the research purpose and objectives, define relevant terms and concepts, and indicate the format and strategy for analysis. These considerations define and delimit the scope and methods of the analysis.

Research Need

The central purpose of managerial studies is to examine how and why, and under what conditions, organizations can and do operate "successfully." In pursuit of this objective, organizational theorists have noted that an increasingly significant factor affecting differential levels of organizational "success" is an ability cope with and adjust to rapid and perpetual change. Increasing environmental complexity, dynamism and uncertainty create pressures to develop more responsive and adaptive organizational forms. This concern is explicit in the management and practitioner literatures emphasizing the processes of internal/external analysis, the development of appropriate strategies dependent upon that analysis, and the implementation of programs, practices and policies designed to enhance organizational functioning.

Purposeful alteration of internal organizational arrangements presumes some understanding of the effects of such efforts. Planned responses to anticipated external change presumes some understanding of the effects of those external contingencies on current internal arrangements. At the applied and practical levels, an understanding of how organizational systems respond to external contingencies or to alterations among internal elements – i.e., an understanding of the process and mechanisms of organizational change – is crucial to managerial efforts. Presumably, a better understanding of these interactions should result in an increased ability to predict and control organizational outcomes – leading to greater success in the management of organizations.

Internal versus External

Taking the premise of increasing rates of change as given, an understanding of interactions *among* internal elements and *between* the internal and external organizational environments becomes more than an interesting theoretical diversion. Organizational theorists have long made efforts to deal with the complexities of organizational existence in more realistic and comprehensive ways. Early management and organizational theories (e.g., the administrative school) clearly reflect an internal focus where organizational success is determined by managerial efforts to structure internal arrangement in the most efficient manner. At the opposite extreme, an ecological perspective argues for the primacy of external contingencies – that is, environmental factors are determinative in explaining differential rates of organizational success and failure.

Between these extremes, an open systems perspective emphasizes the importance of interactions between a system and the environment in which it is embedded. Contingency theory, derived in large measure from systems theory, is central to most contemporary theories of management and business strategy. From a contingency perspective organizational success, however measured, is dependent on the "fit" between internal and external contingencies but there is no "one best way" in which this fit is obtained. Successful organizations are those that best align internal arrangements with respect to criteria that are characteristic of a separate and pre-existing external reality such that the organization functions effectively in its operative environment.

In each case, there is clearly a fundamental assumption as to the relative significance of internal versus external factors in explanations of organizational change phenomena. In the first case, "classical" theory assumes that change proceeds from the micro to the macro. Micro-level changes affect organizational functions. In turn, changes in organizational functioning affects the environment in which the organization operates. An ecological perspective reverses the causal arrow by contending that change proceeds from the macro to the micro. Environmental (i.e., macro-level) changes are the primary causal agents and organizations must either adjust or fail.[1] From these perspectives, *either* micro- *or* macro-level factors are fundamental to the process of organizational change. The contingency perspective implies that *neither* micro- *nor* macro-level factors are necessarily most fundamental but that each may predominate, depending on the particular circumstances at a particular time.

The point suggested here is that the issue of micro- and macro-level interactions must be addressed in any consideration of the processes and mechanisms of organizational change. There is a need in organizational

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[1]Of course, in its extreme form, an ecological argument holds that organizations cannot change quickly enough (because of the forces of stasis and inertia) to adapt to environmental change. Changes in organizational forms occur only through "births" and "deaths." The implications and premises underlying this contention are developed in greater depth in a later section.

studies for an approach that can bridge the micro—macro gap. Contemporary organizational theory, regardless of the particular theoretical approach, treats micro and macro as dichotomous – discrete and distinct – elements. Implications from the complexity sciences, as will be discussed in Part II, call this dichotomy into question.

Subjective versus Objective

At an applied level, a contingency perspective suggests that successful managers are able to accurately apprehend those relevant characteristics of the environment in which their organizations operate. Accurate assessment of the organization's external environment – coupled with a clear understanding of the organization's internal environment and the functional relationships between internal components – allows for the development of successful organizational strategies. Such strategies take advantage of internal strengths to exploit external opportunities and to minimize internal weaknesses while guarding against external threats. The particularly astute observer is able to extrapolate from this knowledge base to anticipate future trends and contingencies. Implicit in this is the assumption that managers and strategic planners need to make (constantly improved) mental representations (e.g., cognitive maps, frames, or schema) of an ontologically real and preexistent, but constantly changing, external reality. These subjective representations of an objective reality are manipulated in order to solve organizational problems. This occurs through the structuring of perception into discrete elements and tasks, the application of rule-based methods of modeling to those perceptions, and acting appropriately upon those mental models to ensure or enhance the organizational-environmental fit. Thus, management involves breaking "reality" into its fundamental elements (i.e., analysis), understanding the functional and nomological relationships (i.e., the "laws" and mechanisms) that link those elements, and then to utilize that understanding (i.e., synthesis) to predict and control organizational behaviors.[2] These actions include defining a mission and vision for the organization, conducting internal and external audits, crafting or formulating strategies and tactics, and setting goals and objectives. Such analyses and activities are utilized in aligning internal structures and elements to function in the most efficient and effective manner, given the specific internal and external contingencies.

The managerial and organizational task, from this perspective, is to develop better cognitive models that more accurately reflect the critical contingencies[3] in the external environmental reality. An understanding of the relationships between objective external contingencies that these subjective models represent allows for effective adjustment, alteration and alignment of internal components of the organization so that they better fit with environmental contingencies. Such efforts should result in more powerful organizational performance. Success is, thus, dependent on the rigor of the

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[2]This logic is suggested by Letiche (1997).

[3]In the strategic management literature, the significant external factors are usually referred to as key success factors" and "environmental driving forces."

(external and internal) analysis, the accuracy and appropriateness of the (cognitive) representation(s) of that analysis, and the closeness of the fit between the objective environment(s) and subjective assessment.

As related to the problem of organizational change, this raises the question of the relative importance of subjective and objective elements.[4] Is subjective judgement and assessment the crucial element or are objective externalities most significant in explanations of change in organizations? Do changes in organizational arrangements depend primarily on objective reality or on the subjective assessment of that reality? Does the environment "create" the organization by constraining and defining viable alternatives or are these "objective" features in some way created through the process of subjective assessment? If the answer is that both objective reality and subjective assessment are crucial in explaining how the organization changes, what mechanisms link the subjective to the objective (and *vice versa*)? As with the micro—macro dichotomy, there is a need for a theoretical perspective that

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[4]An apocryphal story illustrates the difficulties in separating the objective from the subjective. A young couple is moving to a new town. During their initial visit to the town, they stop and ask an old gentleman whether the residents are friendly and welcoming to "outsiders." People at the last place they lived were extremely friendly and accommodating, and they hoped that they were just as friendly in the new town. The old man replied only that "You'll find that the people here are just like those in your old town." They moved and found this to be the case – people were just as open and friendly as in their last town. A few weeks later, another couple found themselves in the midst of a move to the same town. They happened to ask the same gentleman the same question – whether the people of the town were open and friendly. People in the last place they lived were extremely closed and unwelcoming and they hoped that would not be the case in the new town. The old man replied only that "You'll find the people here are just like those in your old town." They moved and found this to be the case – people were just as closed and unfriendly as in their last town. In some cases, subjective assessment, perceptions and expectations may become self-fulfilling and "create" the objective, experienced environment.

bridges the subjective—objective gap. The promise of the complexity approach is that it offers a perspective that can resolve these dichotomies and provide an explanation of the mechanisms that link the subjective to the objective.

Prediction and Control

At a more fundamental level, the issues of prediction and control are inextricably linked and are at the core of management and the administrative disciplines. In some sense, the very concept of *management* presupposes the theoretical possibility, if not practical ability, to predict organizational outcomes (at least over some meaningful or relevant time horizon). The notion of control, in turn, presumes an ability to guide the organization in the direction of the desired (and predicted) organizational state or outcome. Management, as it is commonly understood, is thus fundamentally based on the twin concepts of predictability and control of organizational change processes. In turn, an implicit belief in an ability to predict and control organizational outcomes presumes some understanding of the mechanisms and processes of organizational change phenomena. This presumes, in turn, some understanding of the linkages between micro- and macro-level forces, and the relationship between subjective assessment and objective reality. One must know and understand how and why a system "works" if the behavior of that system is to be predicted and controlled. The complexity sciences provide new insights into the problem of prediction and control.

Purpose and Objectives

In a period of organizational restructuring and downsizing, increasing globalization of the world's economy and transition of the U. S. economy from a manufacturing base to an information/knowledge base, the practical and applied problem of contending with change becomes critical. Such issues – coupled with a perceived need to create more flexible and responsive organizational forms in an increasingly volatile economic environment – intensify the need for a theoretical perspective that has practical and applied uses. Many perspectives and approaches to explain change in social systems have been posited. However, none have attracted common acceptance nor attained consensus status (Scott and Meyer, 1994). Despite an enormous amount of research, many questions and uncertainties remain concerning organizational change processes. The impetus for this research is the contention that unless (and until) researchers are able to adequately deal with change phenomena at a theoretical level organizational theory has little to offer the organizational practitioner.

Research Issues

At the theoretical level, the issues and problems surrounding efforts to understand *organizational change and transformation* have been of central and enduring concern for organizational analyst, theorist and practitioner alike. These issues pose, for many, the central theoretical challenge to the organizational sciences (e.g., Greenwood and Hinings, 1987; Quinn and

Cameron, 1988; Pondy, Boland and Thomas, 1988; Hinings and Greenwood, 1988; Van de Ven and Poole, 1995). The lack of a dominant theoretical perspective to guide either practical efforts or academic research programs in the organizational sciences is due in large part to differences in the metatheoretical foundations and assumptions upon which theoretical approaches are based. This *fragmentation and lack of paradigmatic consensus at the level of metatheory* contributes to the lack of consensus and fragmentation at the level of substantive theory. Further, it presents a severe obstacle and impediment to scientific growth in the organizational disciplines (Pfeffer, 1993; Zammuto and Connolly, 1984). Such paradigmatic fragmentation has engendered theoretical and methodological controversy and stimulated research efforts that continue to enliven the field (e.g., Schultz and Hatch, 1996).

Theoretical approaches to an explication and understanding of social change and transformation processes are, in large part, predicated on assumptions about the limits, if any, to the prediction and control of social and organizational outcomes. Much of current organizational research and analysis (i.e., the methods and methodologies) rest, at least implicitly, on notions of prediction and control that are rooted in the cognitive doctrine of positivistic realism. The models and explanations of organizational change phenomena developed by organizational researchers, particularly those researchers working within this dominant positivistic framework, are predicated on the *theoretical* possibility of prediction of future organizational states. These assumptions, the "pillars of modern science" (Young, 1991), are being increasingly called into question by the complexity sciences. Though the complexity sciences may have wide ranging implications for the social sciences, consideration is limited here to two central issues:

1) *How can the complexity approach be best utilized to extend and improve our* ***theoretical*** *understanding of how and why social organizations change, transform and adapt?*; and,

2) *What implications do the complexity sciences have for an ability to predict and control such change?*

The question, of course, is not whether prediction is a *practical* possibility; the need for contingency planning is a central concept in the field of strategic management, for example. The important question involves the *theoretical* limits to predictability. Assumptions as to the theoretical limits of prediction rest, in large measure, on the metatheoretical underpinnings of the specific theoretical approach. Moreover, theoretical approaches and their metatheoretical foundations determine, in large part, the methods and methodologies utilized to explore the practical implications of the approach.

The central contention is that the metatheoretical, theoretical and methodological levels are ultimately inseparable and must be considered conjointly (Figure 1.1). The primary objective of this research project is to examine these metatheoretical and theoretical issues within the context of the emerging complexity sciences (Figure 1.2). Though developed outside of the social sciences, there is a growing literature and body of research that suggests the complexity perspective offers profound implications for the conduct of inquiry in all scientific fields and, thus, has begun to attract the attention of social scientists.

The concerns driving this research effort are summed up in an article by Begun (1994), in which he notes some of the problems associated with the application of insights from the complexity sciences to organizations and organizational theory. The critical issue facing organizational researchers is theoretical, not one of assessing the methodological and empirical implications of the complexity approach and, thus,

> ...it would be inaccurate to state that the challenge facing organization science is to *apply* chaos and complexity theory. The challenge is to discover chaos and complexity theory for organization science, knowing them for natural science. It is not an issue of extrapolating, extending, or applying findings from natural science. We need to discover our own questions and theories, informed by this new understanding of nature. We need to capitalize on, augment, contribute to, and build chaos and complexity theory (Begun, 1994: 332).

Research Purpose

Building upon this suggestion, the primary purpose of this research is thus:

> *To develop a theoretical approach to the study of developmental and transformational change in social organization that integrates the implications of the complexity sciences, while remaining grounded in current knowledge of organizational and social processes.*

Analysis of this issue will entail some consideration of the ontological, epistemological and methodological foundations of the complexity sciences and their relationship to those of "traditional" or "mainstream" organization theory. Attempts to integrate implications from other scientific fields demand an analysis of these foundations for, as Marsden (1993: 94) notes, "...any theory of knowledge entails a theory of the objects of knowledge. Disinterest in such philosophical matters is not a legitimate concern. The question is not whether ontology, but which?" Implicit metatheoretical assumptions and preconceptions *must* be made explicit, especially when the research agenda is cross-disciplinary.

Physical, Natural and Social Sciences

The appropriation, integration and application of theoretical approaches developed in the physical and natural sciences has a long and varied history in the social sciences (Kiel and Elliott, 1996). Many of the conceptual and theoretical approaches in the organizational sciences have their roots in the physical (e.g., Lewin's field theory) and natural (e.g., the ecological approaches) sciences. Much of economic theory, commonly held as the most "scientific" of the social disciplines, is firmly rooted in the equilibrium approach of classical physics.

Often, however, perspectives developed in the physical and natural sciences are applied to social phenomena with little, if any, attention to the context within which they were originally developed. A cross-pollination of the sciences is fruitful and beneficial – new perspectives open new possibilities, at the very least in the way that issues and problems are conceptualized. However, an adequate understanding of the *original* purposes of the theoretical approach is a necessary prerequisite to application in a new domain or to new phenomena. This is the case even if the perspective is used in an analogical or metaphorical manner only, for there must be an adequate understanding of the literals of the metaphor for it to be of any use (Polley, 1997).

While insights from the physical and natural sciences may serve to broaden and enhance an understanding of social system behaviors, it must be emphasized that there are fundamental differences between physical/natural systems and social systems. Care must be taken when attempting to integrate findings from one scientific area into another. Insights gained should enhance and extend, not replace, understanding. Not only must similarities between the phenomena of interest be addressed, but differences must also be specified.

In this sense, this research should not be viewed as a process of developing a "new" organizational science, but rather as an application of an existing scientific perspective which is itself an extension of "traditional" science. As used here, the meaning of science should be understood in its broadest context. Science is not a particular collection of specific tools and/or techniques, but rather a search for "...more or less general relationships between properties of nature, when the test of the truth of a relationship lies finally in the data themselves" (Homans, 1967: 4). From this definition, it follows that what makes a science is its aim, not its results or particular methodologies and the *new* sciences are not really new. What ***is*** "new" about the complexity approach is not the ultimate goal, objective or aim, but rather the implications, results and methods which derive from them. This project endeavors to apply these implications, results and methods to an analysis of social system behaviors.

Definitions of Change Related Terms

Several recurring terms are defined in this section. These definitions generally follow those proposed by Van de Ven and Poole (1995). The definitions are intentionally broad but are offered as a point of departure. Greater specificity will be attached to the terms in later chapters.

Process is used to refer to the ordering and sequencing of events in an entity's existence over time. This progression of events is not to be confused with two common connotations. First, process (as used here) does not denote an underlying logic utilized to explain causal relationships between independent and dependent variables in variance theories (e.g., "process" theories of motivation). Second, neither is it a description of a category of organizational actions and/or activities (e.g., the strategy making "process" or the communications "process"). Though these uses of "process" are common in the organizational literature and may be useful in explaining organizational outcomes, they generally ignore the temporality of change phenomena. The sense in which process is used here is to suggest descriptions and explanations of how events unfold, change, develop or transform over time (Long, White, Mathews and Peiperl, 1999).

The term *entity* is used broadly to denote any conceptual category of organizational activity (e.g., an individual's job, a class of jobs, a particular strategy), organizational characteristic (e.g., the organization's structure, form or strategy), or organizational membership (e.g., the individual, group, or overall the organization). This generally refers to the "content" of the change phenomena or "what" changes. A *system* is a collection of spatially interrelated and temporally interacting entities. Thus, one may focus on a system of activities, a system of characteristics, or a system of membership categories. The specific meaning attached to these terms (entity and system) are, therefore, relative to the particular study or research effort and depend on the level at which the analysis in performed.

Change is an empirical observation of some difference in form, quality or state in the entity or system over time. A *change process* is the progression of change events that unfold during the entity's or system's existence. This process may be gradual, continuous, incremental and self-sustaining (*developmental change*) or it may be sudden, discontinuous, radical and revolutionary (*transformational change*). The study of developmental change is primarily concerned with how the system maintains its identity and continuity with its past in the face of a constant influx of new components, new strategies and responses to a changing environment. Transformational change focuses more on how the system overcomes the forces of inertia and breaks with its past history. In either case, there is a temporal aspect to changes in the spatial characteristics of the system. A *process theory* is an explanation of how and why the entity or system changes its spatial characteristics and develops or transforms over time.

Format and Strategy for Analysis

The fundamental premise driving this project is that the incorporation of the emerging complexity sciences into organizational theory will have profound effects on the way organizational phenomena are conceptualized and characterized, on the manner in which organizational analysis proceeds, and on the general development and advance of the organizational sciences. Thus it becomes imperative to trace out and develop issues and implications, at several levels of analysis, that this "new" systems science may offer researchers defining "organization" as central to their research efforts (Long *et al.*, 1999).

Research Strategy

The issues surrounding the incorporation of the complexity sciences into organizational studies are complicated and research into this area of inquiry is fraught with peril and "dangerous" in the sense that the payoff for effort devoted to the area is uncertain. As Kauffman and Oliva (1994) note in reference to catastrophe theory, this is not an area of "safe" research. How then, should the subject of complex systems and the complexity sciences be addressed? What is the most appropriate manner in which these perspectives can be integrated into more traditional approaches to the study of organizational phenomena? How can these perspectives be best utilized to extend what *is* known about organizations and the behaviors of their members?

One strategy would be to empirically examine implications following derived from the complexity sciences. Indeed, this is the approach taken by many economists attempting to incorporate chaos research into economic and financial theory (e.g., Blank, 1991; Bullard and Butler, 1993; Carleson, 1991; Chavas and Holt, 1993; Craig, Kohlhase and Papell, 1991; Day and Pianigiani, 1991; Hsieh, 1991; Hughes-Hallet and Fisher, 1990; Hurst and Zimmerman, 1994; Invernizzi and Medio, 1991; Yang and Brorsen, 1992). This inductive and empirical approach is probably the strategy preferred by many "traditional" researchers. As the discussion to this point suggests, however, the complexity sciences have implications for the social sciences beyond the level of methodology and empirical analysis. Implications at the metatheoretical and theoretical levels must be explored and developed before meaningful empirical work can proceed. To this end, a deductive strategy is utilized to integrate the complexity sciences into organizational analysis. However, it is acknowledged (and affirmed) that both inductive and deductive modes of analysis are ultimately necessary.

This research strategy is suggested by Gregersen and Sailer (1993) who urge researchers to

> ...take chaos theory frameworks and apply them to a wider range of research problems at either a *theoretical* or *philosophical* level in order to assess the potentially chaotic nature of social phenomena and develop better methods for modeling such phenomena (Gregersen and Sailer, 1993: 798-799; emphasis added).

Thus, the choice of a deductive research strategy is based on two major contentions. First is the contention that before empirical work can proceed with any guidance and direction, the approaches must be integrated at a more general level. Second, the incorporation of these perspectives provides insights and suggests a resolution to many of the most basic and fundamental questions that continue to perplex organizational researchers. While empirical work is a necessary corollary to the effort presented here, a firm grounding at these "higher" levels of analysis is the current critical need. Theoretical integration is logically prior and a necessary prerequisite to guide subsequent empirical and substantive work.

Research Method

Constructing and testing theory that contributes to a scientific discipline is central to the mission of scholars of that discipline. There is, or at least should be, an intimate reciprocity between the practical problems experienced by practitioners, theories developed by scholars to explain those experiences, and the data and methods utilized to link theory to experience and provide solutions to those problems. There is a danger, however, when research efforts are driven by practical and applied considerations to the exclusion of theory development, as is so often the case in research conducted in business schools. Contributors to the organizational literature periodically reflect on the problems and limitations associated with the atheoretical nature of much of the published research in the field (e.g., Sutton and Staw, 1995; Weick, 1995; Zald, 1996; see also the 1989 special issue on theory building in the Academy of Management Review). As Staw and Sutton (1996: 371) note, though there is a consensus that theory *does not* consist of references, data, variables, diagrams, or hypotheses, "...there is little agreement about what constitutes strong versus weak theory in the social sciences."

However, the basic and fundamental purpose of science is theory and theory development (Kerlinger, 1973: 8). The ends of a science are not primarily oriented toward practical application – this is, hopefully, the result of science but not the goal. Particularly, if the organizational "sciences" are to truly be a science, theory development should hold a primary activity of the practitioners of that science. The views of Kerlinger (1973) are offered as a definition of theory:

> A theory is a set of interrelated constructs (concepts), definitions, and propositions that present a systematic view of phenomena by specifying relations among variables, with the purpose of explaining and predicting the phenomena (Kerlinger, 1973: 9).

A theory thus consists of three elements. One, it is a set of propositions consisting of defined and interrelated constructs. Two, it sets out the interrelations among the constructs and presents a systematic view of the phenomena under investigation. Third, the theory offers an explanation of the behavior of the phenomena of interest. This explanation *may* lead to an ability to predict and control the phenomena.

Beyond uncertainty as to what theory is, however, there is considerable disagreement as to the most efficacious method of generating theory. In this area, primary reliance is placed on Turner's (1986) analysis of the elements of theory, assessment of theoretical approaches and of theory building and development in the social sciences. Turner's view is that, if the emphasis of the research program is on the generation of testable theory, the approach to theory building most likely to be fruitful is to rely on analytical modeling techniques. Elements of the analytical model are linked with an underlying scheme of formal propositions (Figure 1.3). Accordingly, "...the most crucial interchange is...between formal propositions and analytical models. There is a creative synergy between translating propositions into models and vice versa. This is the level at which most theory should be couched" (Turner, 1986: 28-29).

Analytical versus Empirical Models

As such, the emphasis is on the development of an "analytical" model, as opposed to an "empirical" model, of organizational change processes. The focus of an analytical model is to capture a picture of *process*, of how variables affect each other over time. As Turner (1988: 17) notes, too often social scientists "...employ simple causal models that document one-way causal chains among empirical indicators of independent, intervening, and dependent variables." Many would agree and acknowledge that this is an oversimplified approach, but argue that such an empirical approach is necessary for advancement of scientific knowledge given the traditional canons of the research process. That actual social processes are much more complex – consisting of mutual and reciprocal causal processes, feedback loops, lags, and nonlinearities – is temporarily ignored in the interest of developing empirically testable models (Tansey, White, Smith and Long, 1996). Analytical models, on the other hand, attempt to "...capture this complexity by accentuating *configurations* of causal effects among generic classes of variables implicated in a basic social process" (Turner, 1988: 17). The purpose is to develop a model of relationships between concepts without the effort being driven by measurement and data collection considerations which may unduly influence an understanding and explanation of focal processes.

This is not to suggest that empirical and causal modeling methods are irrelevant to scientific advances. Few, if any, researchers would go so far as to make this claim. However, empirical methodologies are designed to *test* theory, not to *generate* theory. The critical issues facing researchers interested in integrating the complexity sciences into social and organizational analysis are at the theoretical and metatheoretical levels and the crucial task is to develop and generate testable theory *before* proceeding to empirical work.

To that end, the method utilized in this research project is based on Turner's (1986, 1988) methodology:

1) define a generic property of the social universe (in this instance, organizational development and transformation);
2) compare and contrast several emerging approaches from the physical and natural sciences (i.e., the complexity sciences) and develop implications that may have theoretical application to the social phenomena of interest;

3) develop an analytical (as opposed to empirical) model of organizational change based on these implications, while remaining cognizant of current work in the social arena; and,

4) articulate the abstract principles, in terms of formal propositions, that express the relations between organizational components and offer explanations for the mechanisms and processes of developmental and transformational organizational change.

In the specific case of attempting to integrate the complexity approaches into organizational studies, an analytical (as opposed to empirical) approach is particularly necessary at this time. Without such theoretical grounding, researchers are left with the essentially blind empirical application of these approaches to social phenomena. The complexity perspective is being empirically applied in many areas of scientific inquiry and many of the more intriguing implications have resulted from this effort. However, organizational researchers are uncertain, not only of the empirical and methodological implications of the complexity sciences, but also of the theoretical implications for the field. Certainly, an inductive/empirical approach is fruitful and is the manner in which many of the insights into the behaviors of complex systems have developed. Just as fruitful, and arguably more necessary at this point, is to take the insights and apply them to existing metatheoretical and theoretical problems in a deductive manner. Such theoretical integration can serve to indicate the types of data and methods needed for subsequent empirical analysis.

Evaluative Criteria

Although the ultimate test of any theoretical relationship lies with the data, the adequacy of any theory or theoretical approach can be evaluated with respect to several criteria. An adequate theoretical treatment of any phenomenon should be *comprehensive*, in that it accounts for and incorporates all elements critical to an adequate explanation of the phenomenon of interest. All other considerations being equal, the more comprehensive the theory the greater its adequacy. The theoretical structure should exhibit an internal *coherence* – that is, the logic linking constructs and concepts to one another should be logically consistent and "fit" together. The more coherent and consistent the internal logic of the theory the greater its adequacy. The theory should be *parsimonious* (i.e., it should follow the philosophical "law of parsimony" or Ockham's razor) such that the least possible number of assumptions be made in attempts to explain any ascertained phenomena. That is, "simpler" is "better" – the philosophical equivalent of the "KISS principle." The greater the parsimony of the theory the greater its adequacy.

As suggested above, an adequate theory should *correspond* to observable "facts" – that is, it should be supported by data. The greater the correspondence between propositions and hypotheses derived from the theory and the data collected to test those hypotheses, the greater its adequacy. Finally, the adequacy of the theoretical structure can be evaluated on the *pragmatic* consequences following from its propositions and hypotheses. This pragmatism is particularly significant to the applied sciences where a theory is ultimately judged by its usefulness in day-to-day application – that is, does the theory assist the practitioner in the solution of practical problems. The more practical the consequences of the theory (i.e., the more pragmatic the theory) the greater its adequacy.

Thus, any theory or set of theoretical propositions purporting to explain a particular phenomenon can be evaluated on several (perhaps, at times, contradictory) criteria – comprehensiveness, coherence, parsimony, correspondence and pragmatic grounds (Table 1.1).[5] The "ideal" theory would meet all criteria. However, given the nature of the research agenda (theoretical development and integration) and research method (analytical modeling), the first three criteria are most significant to this analysis. The theory should be comprehensive, in that all critical elements and factors are accounted for. The theory should be internally coherent and logically consistent. Finally, the theory should be parsimonious, given the requirement for comprehensiveness. Given this limited agenda and purpose, it is sufficient to indicate a plausible correspondence and potential for pragmatic application (Sutton and Staw, 1995; Daft and Lewin, 1990). These two criteria – though ultimately and arguably of

[5]These issues touch, of course, on the areas of epistemology and the philosophy of knowledge. Each of these criteria have, at various time and by various thinkers, been proposed at the "true" source of knowledge (for example, Russell espousing a correspondence theory of truth, Bradley arguing for the primacy of coherence, James and Dewey emphasizing pragmatic consequences). The reader is referred to any basic philosophy text for more depth on the issues (see, for example, Gould, 1985).

inestimable import – may be reserved for subsequent testing of empirical models derived from the analytical model under development here.[6]

Need for Theoretical Development

As will be addressed more fully in Chapter 2, existing theoretical perspectives on organizational change processes are, and have been, of limited use to researchers and practitioners. This contention does not address, however, the question of why efforts to incorporate the complexity sciences into organizational analysis can benefit the discipline. What benefits accrue to organizational analysis from the incorporation of the complexity sciences into research efforts? What lack in organizational analysis makes these perspectives attractive? Do we, as organizational and social researchers, really need to import yet another theoretical perspective from the physical and natural sciences? Do these perspectives have anything to offer social researchers beyond metaphorical and analogical argumentation? Such questions drive the research effort.

In many respects, the effort may raise more questions than it answers. However, the posing of appropriate questions may be more important than well-argued, closely reasoned, and "empirically" supported answers to inappropriate,

[6]The criterion of *refutability* (that is, the proposed theory must be subject to refutation and/or verification) is also important. In the terms presented here, this criterion is an element of the correspondence criterion. To show that a theory corresponds to observable "fact" implies that the implications and propositions derived from the theory can be "tested" in some manner. Such a test of propositions and implications logically implies that they are subject to refutation and can be shown as "incorrect."

irrelevant or inapplicable questions. As Kauffman (1993: vii) suggests "...the greater mystery...is not the answers that scientists contrive, but the questions they are driven to pursue." The notion that scientific progress depends on the cementing of more and more bricks in the edifice of scientific knowledge and on the refinement and extension of existing theory (Kuhn's "normal science") begs the essential question of whether the theoretical and empirical structure being built is truly relevant and reflective of real-world problems and concerns. Perhaps researchers should heed the recurring criticisms of practitioners and academics (e.g., Daft and Lewin, 1990) when much of what passes for research in the organizational arena is called into question or deemed irrelevant. Perhaps further refinement of our collective nomological net is not what is necessary; perhaps the foundations upon which that net is built need to be reexamined. Perhaps it is not the limitations of data, methodology or empirical support that underlie the failures of traditional approaches. Perhaps the failure lies at the metatheoretical and theoretical levels of analysis.

Beyond this, however, is an argument that work at the theoretical level is logically prior to empirical work. Both inductive and deductive modes of analysis are necessary for scientific advances. However, without theory to guide and direct empirical efforts, researchers attempting to integrate the complexity perspective into organizational analysis are reduced to "data dredging" or methods driven research strategies. Finding that a stream of data exhibits "chaotic" properties may be interesting, but not particularly useful without some explication of why and how that finding is of import.

Conclusions

This initial chapter suggests that an understanding of the processes and mechanisms of organizational change is a critical issue in organizational studies, for both practitioners and researchers. Management, viewed as either an applied or an academic field, assumes at least some ability to predict and control organizational outcomes. Academic research is conducted with the goal of increasing that ability. Practicing managers enhance their abilities to predict and control their organizations through training (the *raison d'être* of business school programs) or through practical experience. Effectiveness and success at predicting and controlling organizational outcomes assumes some understanding of how, why and under what circumstances organizations change. An understanding of the mechanisms and processes of organizational change is predicated on some understanding of the linkages and interactions between macro and micro forces and subjective and objective features of organizational existence. Thus, an understanding of the linkages between macro/micro and subjective/objective elements is essential to explanations of the processes and mechanisms of organizations change. Such understanding of why and how organizations change is essential to the prediction and control of organizational outcomes that provides the basis for effective management practice and research. These are the fundamental tenets and implicit foundations of management and organizational studies (Figure 1.4).

The complexity sciences hold promise for enhancing and extending an understanding of such processes and mechanisms. However, because the complexity approach takes issue with the fundamental premises and assumptions on which organizational studies are founded, efforts to apply the approach to organizational theory and analysis should focus on theory development before proceeding to empirical analysis. To this end, the chapter outlined a deductive research strategy and analytical modeling methodology for pursuing the goal of theoretical integration.

Though the chapter defines and delimits the scope of the present analysis, it does not present all of the factors relevant to the analysis. The chapter suggested, but did not develop arguments to support the contention, that contemporary theoretical approaches to developmental and transformational change processes have been, and are, limited. Neither did the chapter discuss the critical issues that must be accounted for in any adequate theoretical explanation of the processes and mechanisms of organizational change. Additionally, though the complexity sciences were referred to at several points in the chapter as offering the potential for extending and enhancing organizational theory, the components and implications of the complexity approach were neither defined nor developed. These concerns are addressed in the remaining chapters of Part I. Chapter 2 focuses on the change related issues. Chapter 3 introduces the elements of the complexity sciences.

CHAPTER 2

RESEARCH PROBLEMS

Chapter 1 argued that an understanding of organizational change is fundamental to the managerial disciplines. This chapter extends the argument by developing the substantive issues involved in understanding and explaining the mechanisms and processes of organizational change phenomena, including a consideration of the limitations of contemporary theoretical approaches. The critical issues that must be addressed by any theoretical perspective attempting to overcome such limitations are developed. Finally, the paradigmatic and metatheoretical issues underlying theoretical approaches to organizational change are introduced.

Organizational Change

As Van de Ven and Poole (1995) note, organizational change and transformation are issues of central and enduring importance to organizational theorists. Moreover, the issue of change represents, for many, the essential or pervasive character of reality (Wagner, 1995). However, the processes and sequencing of events that explicate how and why social systems change "...have been difficult to explain, let alone manage" (Van de Ven and Poole, 1995: 510). This state may constitute one of the major challenges facing the social sciences (see, for example, Benson, 1977; Fombrun, 1986; Monge, 1990).

The issues involved in describing and tracing the processes and sequencing of events are so complex and interrelated that reduced models which rely on simple causes, unidirectional cause and effect relationships[1] and which force explanation to one level or another have not been satisfying at the theoretical level nor very useful at the practical and applied levels. Astley and Van de Ven (1983) argue that attempts to pose and answer broad questions regarding social phenomena, such as organizational change, are inhibited by traditional research methodologies by noting that:

> Unfortunately, the interesting aspects of these questions are often destroyed when attempts are made to represent these observable patterns in theoretical models. Because of training, socialization, and cognitive limits, theorists tend to reduce these observed complexities to unidirectional causal models among a limited set of factors that are viewed in isolation from other variables (Astley and Van de Ven, 1983: 267).

This state is relegated not only to the social sciences but applies to the sciences in general. Puccia and Levins (1985) argue that

> ...as the sciences have developed, we have been most successful in the detailed characterization of pieces of problems. But we have been ill prepared for solving, or even posing, broad problems. Most of the major failings of contemporary applied sciences have come about despite an increasing precision in the small (Puccia and Levins, 1985: 1-2).

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[1]As Weick (1979: 52) notes, "...when any two events are related interdependently, designating one of those two 'cause' and the other 'effect' is an arbitrary designation."

A prime example in the organizational sciences of this failure is the inability to come to grips with the broad problem of organizational change and transformation. Despite an enormous amount of effort and interest, many questions remain concerning change phenomena and change processes. How are the issues of continuity and change, stability and transformation, inertia and development related? Are they mutually exclusive, paradoxical concepts or does a consideration of one imply, of necessity, the other? How can a system maintain its identity and stability while at the same time retain the ability to respond, develop and change over time?

More specifically in the social and organizational arena, what are the fundamental types of change processes that social systems exhibit? How do organizational transformations occur? Do organizations evolve gradually or is change discontinuous and radical? What "drives" or provides the impetus for organizational change? Are changes induced through endogenous or exogenous factors? At an even more basic level, these issues suggest some conceptualization of what is it that changes. What characteristics or components (i.e., what unit of analysis) are addressed in the theoretical arguments? Can changes in these organizational components, characteristics or elements be designed, controlled and directed? These are only a few of the questions being asked but have not been satisfactorily answered by organizational researchers engaged in an exploration of change and transformation phenomena. Lack of satisfactory answers to such questions serves to highlight the limitations and failures of traditional and contemporary theoretical approaches.

Failure of Traditional Approaches

Benson (1977), arguing from a Marxist perspective, noted this failure to deal with fundamental problems associated with change more than twenty years ago by contending that:

> Despite the central importance of organizations to thoroughgoing social reconstruction, the study of organizations has not developed a capacity to deal with fundamental change. Instead, established approaches tend to affirm present organizational realities and to deal with relatively minor adjustments within the present order (Benson, 1977: 19).

Likewise, Fombrun (1984: 404) suggests that the failure of researchers to appreciate the centrality of change results from the fact that contemporary "...organizational research has overemphasized the study of stability rather than change, thereby paying greater attention to processes of convergence rather than divergence."

Even those theoretical approaches with change phenomena as central to their problematic are lacking in this regard. For example, though a consideration of change (or at least relative rates of change of internal and external components) is fundamental to the ecological perspective and is of prime concern to evolutionary approaches, theorists working within an ecological/evolutionary framework "...do not have a fully developed theory of organizational evolution" (Baum and Singh, 1994: 4; Singh, 1990; Hannan and Freeman, 1989). The institutional approach, with a similar emphasis on change processes, has failed in this regard. As institutional theorists Scott and Meyer (1994) argue, change is

> ...an issue not well dealt with in modern organizational theory...We have to date developed little by way of a general or macrosociological model of long-term or widespread organizational change...Earlier, crude evolutionary models...have been discredited, and more recent attempts to improve them...are still in their infancy (Scott and Meyer, 1994: 7-8).

This failure to develop an adequate theoretical understanding of organizational change processes has profound implications at the practical/applied levels of analysis. March (1981) argues that:

> ...a comprehensive development of managerial strategies...*requires a more thorough understanding of change in organizations*, not a theory of how to introduce any arbitrary change, but a theory of how to direct somewhat the conventional ways in which an organization responds to its environment, experiences, and anticipations...<this argues> for considering the fundamental adaptive processes by which change occurs, in terms of broader theoretical ideas about organizational action (March, 1981: 575; emphasis added).

Contributing to this failure to develop an adequate understanding and explanation of the broad problem of social and organizational change is that much of the research has been *ahistorical*, *acontextual*, and *aprocessual* (Pettigrew, 1985).

<u>History</u>. First, cross-sectional, synchronic studies tend to ignore the impact of past actions and structures (i.e., historical effects) on current and future organizational phenomena. History does matter in explaining how organizations and organizational structures change and develop. Much of organizational research, however, fails to incorporate such temporal

contingencies into explanations of organizational phenomena. Organizations may be better conceptualized as self-referential and recursive feedback systems, where today's actions, activities and structures affect and, in some sense, determine tomorrow's structures and activities.

Context. Secondly, even if longitudinal, diachronic data are utilized, reductionist methods abstract out, or intentionally ignore in the interests of manageability, many of the complexities and potentially confounding factors in empirical examinations of change in organizational settings (Allen, 1988, 1994). This "reductionist" strategy follows from a perceived need for precise measurement of significant variables and control of potentially confounding factors (Puccia and Levins, 1985). However, the resulting lack of appreciation of context has led to highly rationalized linear models of change processes that focus on phenomena at a specific level of activity but are intended to apply to a broad class of organizational systems and/or subsystems (White, Tansey, Smith and Barnett, 1993).

Process. Finally, much of the literature on change and innovation has tended to view change as "...the unit of analysis, and change itself either as a single event or a set of discrete episodes" rather than as a continual, ongoing dynamic process (Pettigrew, 1985: 23; see also Van de Ven, 1992; Mintzberg and Westley, 1992; Monge, 1990). Processes of change are ignored through a focus on the *event* of change and "...studies of transformation, thus, are often preoccupied with the intricacies of narrow *changes* rather than the holistic and dynamic analysis of *changing*" (Pettigrew, 1987: 655).

Any theoretical treatment must incorporate historical, contextual and processual elements if it is to overcome the limitations and failures of existing theoretical approaches.

Critical Issues

Thus, beyond issues dealing with the "what" of social and organizational change (i.e., a specification of the focal entity, its components and their functional relationship) an adequate theory should include historical, contextual and processual considerations. Moreover, current perspectives (e.g., White *et al.*, 1997) suggest that any theoretical approach purporting to supplant or extend existing approaches must, at a minimum, address and offer an account for four critical issues. These include

1) the *driver* or motor of change;
2) the *director* of change;
3) the *locus* of the driver/director or the source of change; and,
4) the *modality* of change.

Though closely interrelated, these issues are conceptually distinct (Table 2.1).

Drivers or Motors of Change.

Drivers of change provide the impetus, or generating force, for change. The population ecology perspective reopened (or perhaps revitalized) the debate in organization theory over why and how organizations change. Ecological perspectives extend the systems theory insights into the importance of environmental factors by giving such external factors primacy – organizations are relatively inert entities and fundamental structural change is explained through mechanisms operating at the environmental level. In ecological or selection theories, change is driven by *competition for scarce resources* between populations of organizational forms (Hannan and Freeman, 1984). Competition for scarce resources insures the "survival of the fittest" such that forms most suited to acquire required resources are successful and non-competitive forms are unsuccessful and the species (i.e., form) eventually dies out. It is this competition for survival between *populations of individuals at an environment level* that provides the motive force for change. This suggests that, in the terminology of organizational theory, the critical competitive rivalries exist between organizational forms and structures, not individual organizations.

Similarly, adaptation and coevolutionary theories (Singh, 1990; Baum and Singh, 1994; Van de Ven and Poole, 1995, include dialectic theories) tend to place the generative force for change at the environmental level. Rather than competition between populations of organizational forms, however, a mismatch, conflict, or lack of fit drives change processes *between organizational capabilities and environmental contingencies*. The organization is able to adapt internal characteristics *in response* (i.e., it reacts) to changing environmental factors; births and deaths are not the only method through which changes in organizational forms are realized. In this instance, even though organizational actors may direct change (i.e., adaptation) processes, the generating force for change does not lie with the decision-maker. Change at the environmental level forces the organization to make adaptive (responsive) changes in internal structural and strategic arrangements. Thus the motive force, or driver of change, is external to the organization.

Organizational change may also be driven by forces or laws operating at the level of, or internal to, the organization. In life-cycle and stage theories of organizational (and system) development, change is conceptualized as driven by a *natural progression through a series of developmental stages* (Van de Ven and Poole, 1995). The stages through which the organization passes are discrete and distinguishable in form and function from each other. Though the stages are distinct, the change process is usually gradual enough that the system retains its essential character and identity throughout the process. The significant point is that change is driven by mechanisms (e.g., by rules, logic or laws) internal to the system that operate irrespective of environmental characteristics.

Also locating the change driver internally are theories such as strategic choice and transaction cost economics that place the generating force for change in the *teleological mechanism of goal enactment and attainment.* Change is driven by the intentional acts and actions of organizational participants, not as a reaction to external disturbances, but rather proactively *in* *anticipation* of environmental change. Organizational decision-makers discern some need for change (e.g., an opportunity presented by external factors or for improved internal efficiencies) in organizational arrangements and goals and objectives are established related to those opportunities. New arrangements are structured that allow for the attainment of those ends. The conscious behavior and intentional action in pursuit of these goals and objectives drive change. Much of the management, organizational development and strategic management literature assume this perspective as to what drives organizational change. The task of management, from this perspective, is to focus on setting goals for the organization that will increase its effectiveness and efficiency and to take conscious steps to attain those goals. Thus, change is driven by mechanisms internal to the organization.

Directors of Change. As opposed to the driver of change, which provides the generating force or impetus for change, directors function to guide or steer change along a particular path (White *et al.*, 1997). Rational adaptation, transactions cost economics, strategic choice, coevolutionary and dialectic theories tend to hold that changes in organizational arrangements are guided and directed by the conscious decisions and/or intentional actions of organizational actors and, thus, locate the director of change internal to the organization. These theoretical approaches generally assume that organizational structures, activities and members are relatively malleable and can be modified by organizational participants. Such directional modifications are based either on some notion of contingency and/or fit between internal capabilities and external realities. Direction is internal to the organization and result from either the *conscious goal directed (proactive) decisions of organizational members* or as a *rational (reactive) adaptation to environmental change* to enhance the internal efficiencies and effective operation of the organization.

Even in approaches where change processes are internally directed, change phenomena may be driven by external contingencies. In such cases, the concept of social inertia plays a central role. Inertial effects result in forces for change that are internally directed but externally driven. For example, in the approach suggested by Laughlin (1991), who builds on perspectives introduced by Hinings and Greenwood (1988) and Pettigrew (1985, 1987), organizations tend toward a balance and coherence (i.e., equilibrium) between internal components (i.e., interpretive schemes, design archetypes, and sub-systems) and that:

> Once such a balance and coherence is achieved at some level...'inertia' around this dominant perspective becomes the norm. It is only an *environmental* disturbance which will require organizational participants, however reluctantly, to shift the inert characteristics of organizational life (Laughlin, 1991: 213; emphasis added).

Lewin's (1951) "unfreeze—move—refreeze" model of planned change is one of the earliest and most often referenced example of the implications of this approach (Huse and Cummings, 1985; Harvey and Brown, 1996). In this case, change may be internally directed but the motive force (i.e., driver) is external to the organization as exemplified by the "environmental disturbance." Management reacts to those driving forces in the external environment, but retains the ability to control the direction of the internal change processes. An essential task for the change agent or decision-maker is to first recognize the externally generated forces for change and then to "unfreeze" the organization and its members from the inertia and stasis in which they are mired. The organization can then move (as directed by management) to its new state, where internal arrangements are in alignment with external environmental realities. When the desired arrangement is attained, the organization is "refrozen" into its new internal alignment. These new arrangements remain in place unless, and until, a mismatch between internal and external contingencies serves to drive the organization to new arrangements. In this case change is directed by internal mechanisms but is externally driven.

Selection (ecological) and life-cycle (stage) theories place control of the direction of change outside of, or external to, organizational actors and participants. In the case of selection theories, change is directed by *selection mechanisms* operating at the environmental level. In the case of life-cycle or stage theories, superordinate or predetermined laws, rules or some logical program directs change and guides the organization through its developmental stages directs change. In both of these, the direction of change is outside (or external) to control of organizational participants.

Sources of Change. Explicit in the argument above is the notion that the locus of the driver and director may be either exogenous or endogenous to the organization. Speculation and theorizing about the source of change is not new to the social and organizational sciences. For example, Hannan and Freeman (1984: 150; 1989: 10-13) suggest three general theoretical perspectives on the source of organizational change.

Selection theories (e.g., organizational ecology) place the environment in a determining position where organizational variety results from the creation (i.e., "birth") of new organizations and organizational forms and the replacement (i.e., "death") of old ones. *Rational adaptation theories* (e.g., Child, 1972) propose "...that organizational variability reflects designed changes in the strategy and structure of individual organizations in response to environmental changes, threats, and opportunity" (Hannan and Freeman, 1989: 12). Thus, the rational adaptation perspectives hold that structural change is a planned response to changing circumstances (e.g., changes in environment, technology, resource availability, institutional factors, or power and control relationships). Finally, *random transformation theories* "...claim that organizations change...mainly in response to endogenous processes but that such changes are only loosely coupled with the desires of organizational leaders and...<the impact of the> environment" (Hannan and Freeman, 1989: 13). March and Olsen (1976), or perhaps Weick's (1979) "enactment—selection—retention" approach, are usually held to exemplify this third type of approach. For example, March's (1981: 566) discussion of the "unintended consequences of ordinary action" is relevant to a conceptualization of change as but loosely coupled to intention.

McKelvey (1982) likewise distinguishes between *allogenic* theories which place the driver and director external to the organization and *autogenic* theories which locate the driver and director internally. However, drivers and directors are conceptually distinct and may be either internal or external. The combinations of internal directors and drivers present different implications for the role of management and the explanations of organizational change processes. These implications range from a view of managerial control as total and absolute to one that suggests that managers and management are largely irrelevant to explanations of organizational dynamical processes (Table 2.2).

The various combinations serve as an organizing framework for arguments in later chapters and as a response to Pettigrew's (1985) criticisms:

> Arguments over the true or basic sources of change, while interesting and worthwhile in the sharpening of academic minds and egos, are ultimately pointless. For the analyst interested in the theory and practice of changing, the task is to identify the variety and mixture of causes of change and to explore some of the conditions and contexts under which these mixtures occur (Pettigrew, 1985: 1-2).

The framework is a step in the direction of identifying the "variety and mixtures of causes of change." Organizational change processes, however, may never be adequately explained as an either/or proposition and may be driven and directed by a combination of internal and external factors specific to the system and its relevant environment. Rather than mutually exclusive phenomena, these factors exist on a continuum where the particular mix of internal and external drivers and directors depends on the "conditions and contexts" of the particular situation under consideration. Moreover, these factors are arguably interdependent and mutually causal. This, of course, presents an empirical question – under what conditions and/or circumstances do internal or external factors contribute most to organizational change processes? What mechanisms explain the hypothesized interdependence and mutual causation? There is a critical need in organizational studies for a theory and theoretical model that can provide guidance for such empirical explorations.

The framework is, however, only partial in that it does not address the modality of change phenomena – completeness forces a consideration is the *type* of change being described.

Modalities of Change. An important distinction in the change literature concerns that of morphostatic versus morphogenic change.

Morphostasis, or first order change, is used to signify marginal change or incremental adaptation to changing circumstances *without* an accompanying change in the fundamental structuring and behavior of the system. This more narrowly specifies the meaning to be attached to *developmental change* introduced in Chapter 1. Derived from the biological literature, morphostasis refers to the processes by which a biological entity maintains it structure and form though there is periodic or regular replacement of individual components. As such, it is clearly related to the physical concept of equilibrium maintenance and homeostasis. In the organizational literature, several authors (e.g., Leifer, 1989; Laughlin, 1991) note the relationship of morphostasis and first order change to concepts familiar to organizational researchers such as Argyris and Schon's (1978) concept of single-loop learning (Table 2.3). Morphostatic change processes serve to maintain system equilibrium, improve system efficiencies and effectiveness and allow the system to remain on its current trajectory through phase space. In this sense, morphostatic change is continuous, incremental and evolutionary.

Morphogenesis, or second order change, refers to the emergence of new forms and structures. Morphogenic change occurs when the system's basic characteristics undergo multidimensional change and transformation and results in a fundamentally new mode of structuring and behavior (i.e., transformational change). In contrast to equilibrium maintaining morphostatic change, second order change is equilibrium breaking and is congruent to Argyris and Schon's (1978) notion of double-loop learning. Rather than maintaining equilibrium and the current trajectory, morphogenic change suggests a sudden, discontinuous change in trajectory. As Thom (1969) notes, morphogenesis "...involves by definition some discontinuity of the phenomenological properties of the medium studied" and is revolutionary or transformational in its effects on system structure and behavior. These sudden, unpredictable and discontinuous periods of change explain why "...morphogenesis...has up to now resisted all attempts of classical mathematical treatment: any quantitative model, using explicit equations, involves necessarily analytic, hence continuous functions" (Thom, 1969: 314). This inability of traditional science to explain morphogenic processes has spurred much of the effort expended by complexity scientists working in the natural and physical sciences. In the organizational literature, the punctuated equilibrium approach introduced by Tushman and Romanelli (1985, 1994) and Fombrun's (1986) convergence/divergence approach represent attempts to deal with these differing modalities of change.

Theoretical Elements

Thus, an adequate theoretical exposition of organizational change must include explanations of the source, modality, driver and director of change, in addition to specifying of the content of change phenomena (i.e., the entity or system of entities under consideration). Further, an adequate theoretical treatment must incorporate historical, contextual and processual elements. The theory must address the issues of macro—micro linkages and the relationship between the subjective and objective features of social existence. Finally, the theory must consider the potential for predicting and controlling the mechanisms and processes described by the theory (Figure 2.1).

An inclusion and consideration of these elements addresses the first criterion for judging the adequacy of any theoretical position – the *comprehensiveness* of the theoretical approach. That is, does the theory include all those elements critical to an adequate explanation of the phenomena of interest? Further, the analytical model must incorporate all of these elements in a coherent and logical manner while maintaining the principle of parsimony in order to exhibit sufficient adequacy.

However, a failure to include and consider the crucial elements and critical issues provides only a partial explanation of the limitations of contemporary theory. The failures may be at least partially attributable to issues at a "higher" – i.e., metatheoretical and paradigmatic – level of analysis. Theoretical approaches to account for these elements and issues are not developed in a paradigmatic vacuum. Theories are constructed within the context of a set of paradigmatic and metatheoretical assumptions that provide the foundation for the approach. When integrating an alternative theoretical perspective, it is incumbent that the fundamental assumptions be explicitly considered. The differences and similarities of the alternative approach (i.e., the complexity sciences) must be compared and contrasted to the fundamental assumptions on which contemporary organizational and management theory are grounded.

To do so forces a consideration and description of issues and problems plaguing the organizational sciences at the paradigmatic and metatheoretical level of analysis. The major contentions are outlined in the following section. These metatheoretical issues have a significance that goes well beyond philosophical discourse. The manner in which they are addressed (and answered) provides the basis for assumptions concerning the linkages between macro- and micro-level forces, the linkages between subjective and objective factors, and the potential for predicting and controlling organizational mechanisms and processes.

Metatheoretical and Paradigmatic Foundations

Two broad perspectives are apparent at the metatheoretical level. First, a segment of the academic community sees the social sciences as dominated by a monolithic paradigmatic structure that limits creativity and inhibits the ability to deal with human, social and organizational problems (e.g., Letiche, 1997). From this view, the majority of contemporary theoretical approaches all adhere to the dominant Newtonian/Darwinian doctrines of evolutionary naturalism and positivistic realism with but minor variations in degree, not in kind. What is needed for scientific advancement in the organizational sciences, from this perspective, is an increased paradigmatic openness.

Alternatively, those researchers working within the dominant paradigmatic framework suggest that the organizational sciences are too fragmented and becoming increasingly "Balkanized" (e.g., Pfeffer, 1993). Scientific advancement requires that the organizational sciences to reach some paradigmatic closure. The general arguments of each view – the "monolithic" perspective and the "Balkanization" perspective, respectively – are briefly outlined below.

The Monolithic Foundations of Contemporary Theory

The failure to deal adequately with the processes and mechanisms of change has been attributed to the fact that much of contemporary management theory and practice remains dominated by ideas rooted in nineteenth century social, political, economic and scientific thought. The problem from this perspective is that the paradigmatic foundation of much of the "modern" management and organizational change literature "...sounds strangely like nineteenth century social Darwinism" (Letiche, 1997: 1). Most current theoretical approaches to the explanation of social change phenomena reflect, at least implicitly, the evolutionist doctrine of social naturalism and the cognitive doctrine of positivist "realism" that provide the foundations of Darwinian evolutionary theory.[2]

The Darwinian notions of *survival of the fittest*, *competition for scarce resources* and *natural selection* have a direct, if sometimes unacknowledged, link to the dominant open systems and contingency perspectives. Natural selection ensures that entities best suited and adapted to the requirements of the external environment are successful in the competition for scarce resources. Natural selection certainly implies that the entities of interest are open to environmental influence and that survival is contingent on a fit between

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[2] It seems intuitive to assert the dependence of Darwinian thought on the Newtonian paradigm. The links between Newtonianism and Darwinianism will become more explicit in Part II.

the capabilities of the entity and the characteristics of the environment in which the entity exists.

In organizational terms, this translates to the idea that the "bottom line" for organizational success is to develop a competitive advantage over its economic rivals. The struggle for (economic) existence is determined by natural (market) selection processes (laws) which favor those firms most well adapted to the particular environment in which they compete. The internal "genetic" composition of the firm (in terms of structures, strategies, strengths, competencies and/or configurations) needs to be optimally adapted to the characteristics of its environment to survive and thrive – i.e., "survival of the fittest." Organizational "fitness" – the company's adaptedness to its market niche – is all-important. The managerial role is to understand the driving forces at operation in the organization's environment, determine those factors which are critical for success in that environment, and align internal arrangements so that they fit this particular set of circumstances. Successful organizations are those most adept at balancing internal operating needs for efficiency with the needs for effectiveness in coping with external contingencies.

This social evolutionary naturalism is thoroughly ingrained in management thought and, coupled with an realist epistemology which suggests that subjective sense experience is a true (if somewhat limited) account of an objective external reality, has a profound affect on conceptions of managerial activities and the management of organizations. A realist perspective implies a position of determinism in that (social) reality is self-existent, self-explanatory, self-operating, and self-directing – it is ontologically real. Because it is posited that the competitive social reality is external to individuals and organizations (i.e., it is an object of social scientific discovery) there is no real reason to question the "rules of the game." The rules can be expressed as positive, quantifiable social "laws" that are discoverable through academic and scientific research efforts. To the extent that these laws are discovered and understood, they can be used to predict (at least within some relevant range) future organizational states and to control activities (at least, within the constraints imposed by those "laws") in efforts to attain organizational goals and objectives.

Differing mainstream theoretical approaches to organizational and strategic management do not propose drastically different models of cognition and/or perspectives on the external realities confronting the organization. Rather, the various approaches compete with one another to analyze more efficiently, model practice more accurately, and to produce more prescriptions leading to managerial success. Even perspectives that, on the surface, appear to be quite at odds with mainstream thought (e.g., organizational ecology) rely quite heavily on these paradigmatic foundations – the differences are more of degree than of kind: the degree of internal (i.e., managerial) versus external (i.e., environmental) control and the issues involved in the conveyance and inheritance of acquired traits [e.g., the degree of difference between cultural and "mimetic" (i.e., Lamarckian) conveyance of acquired characteristics through learned capacities and/or organizational memory versus the (i.e., Darwinian) mechanisms of biological genetic inheritance]. The evolutionist doctrine of social naturalism coupled with the doctrine of positivistic realism underlies both ecological selection theories (where the environment "selects" the most adapted organizations for survival) and managerial choice theories (where decision makers exert enough control over internal arrangements and order the "fit" between internal and external contingencies). In both cases, the theoretical superstructure and paradigmatic foundations are the same – differences revolve around specific (empirical) issues and arguments that derive logically from the basic premises (Stacey, 1995).

The problem, from a phenomenological perspective, with the paradigm is that

> Both cognitivism and social Darwinism are dualist and conflictual forms of thought. Cognitivism is based on the analytic opposition of the complex holistic reality, with a system of rational symbolic computation. "World" is reduced to symbols, which are then manipulated (processed). The cognitive "elements" of problem solving do not resemble phenomenal experience. The "lived-in" world is not organized into discrete elements ready for logical, sequential treatment. Thus only by destroying the experiential *presence* of circumstance, can cognitivists create the mental representations which they feed into their rule based "problem solving." Darwinianism centers on competition for limited resources – i.e., competition is construed to be the driving force of evolution. Neo-Darwin sociobiologists...see an over-riding competitive logic to human existence wherein the *presence* of the other may have reproductive value to the *self*, but not much more (Letiche, 1997: 8).

Ultimately, the Newtonian/Darwinian paradigmatic foundations define away much that is significant and crucial to explanations of human existence. Such a paradigm puts "off limits" many areas inquiry and avenues of research by contending that such concerns are "outside" the realm of appropriate scientific study. Because of such limitations, many see the organizational sciences as dominated by a monolithic scientific framework that serves, not to enhance and extend understanding, but to restrain and inhibit progress.

A Fragmented Discipline and Paradigm Incommensurability

From within the dominant paradigm, however, the organizational sciences are often characterized not as a monolithic whole but rather as conceptually and theoretically fragmented. This fragmentation has "subjected" the discipline to a multitude of theoretical, methodological and empirical approaches (e.g., Koontz, 1961; Ranson, Hinings and Greenwood, 1980; Pfeffer, 1993; Tsoukas, 1994; Schultz and Hatch, 1996). The organizational sciences, from this view, are becoming increasingly Balkanized, with researchers often more interested in protecting a particular theoretical domain than engaging in efforts that would further the "scientific" status of the field.

This diversity of problems, approaches, methods of analysis and vocabularies utilized by organizational researchers is most often seen to be a result of the variety of competing paradigms that guide research efforts. Such paradigms provide the metatheoretical foundations for researchers working within the various and specific theoretical approaches organizational issues. Thus, the organizational sciences are not dominated by a monolithic framework, but by a multitude of competing approaches.

Burrell and Morgan (1979) introduced the *paradigm incommensurability thesis* into organizational studies through an analysis of the reasons for the great variety of approaches to, and theories about, organizational phenomena.[3] They suggest that the multitude of approaches in the social sciences results from the fact that all theories of social phenomena are based on fundamental and contradictory assumptions about the nature of science and on the nature of society and the social world. Ontological, epistemological and methodological assumptions and presuppositions, in addition to assumptions about human nature (i.e., voluntarism versus determinism) determine, either implicitly or explicitly, the problems chosen for study. Further, the theories, models and methods developed to explain phenomena of interest are derived from these assumptions. These metatheoretical assumptions about the nature of science, combined with fundamental assumptions about the social world, define four basic paradigmatic approaches to the study of social behaviors (radical humanist, radical structuralist, interpretive, functionalist).[4]

Distinctions among competing paradigmatic approaches are acknowledged by most social researchers (e.g., Tsoukas, 1994). What is

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[3]Burrell and Morgan's (1979) usage of the term "paradigm" is considerably broader than that by Kuhn (1970). Kuhn defines paradigm as "universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners" (Kuhn, 1970: viii). Burrell and Morgan's usage is more akin to a *Weltanschauung* or a way of conceptualizing "reality." As such "...'paradigms,' 'problematics,' 'alternative realities,' 'frames of reference,' 'forms of life' and 'universe of discourse' are all related conceptualizations although of course they are *not* synonymous" (Burrell and Morgan, 1979: 36).

[4]The incommensurability thesis will be dealt with in more detail in Chapter 6.

problematic, though, is the further contention that these paradigmatic foundations are *incommensurate*; i.e., the paradigmatic approaches cannot and should not be synthesized or integrated. Burrell and Morgan (1979) state quite clearly their belief that a synthesis or integration of the four basic approaches is not possible

> ...since in their pure forms they are contradictory, being based on at least one set of opposing metatheoretical assumptions. They are alternatives, in the sense that one *can* operate in different paradigms sequentially over time, but mutually exclusive, in the sense that one cannot operate in more than one paradigm at any given point in time, since in accepting the assumptions of one, we defy the assumptions of all the others (Burrell and Morgan, 1979: 25).

This contention of incommensurability has received much attention in the literature (Gioia and Pitre, 1990; Hassard, 1991; Hunt, 1991; Parker and McHugh, 1991; Willmott, 1993; Pfeffer, 1993; Cannella and Paetzold, 1994; Redding, 1994; Tsoukas, 1994; Weaver and Gioia, 1994; Schultz and Hatch, 1996). In particular, Pfeffer's (1993, 1995) recent call for the imposition of a paradigmatic consensus as necessary for advancement in the organizational sciences has led to a lively exchange between those favoring paradigmatic closure and those arguing for acceptance and encouragement of paradigmatic diversity (e.g., Cannella and Paetzold, 1994; Van Maanen, 1995a, 1995b).

Theory and Metatheory

The significant point is that all theories and theoretical approaches are grounded in a variety of metatheoretical assumptions that define a paradigmatic way of viewing the world. More to the point, paradigms define and delimit the issues (and, to an extent, the problems) of interest in explanations of social phenomena. The way in which problems are identified and specified, the way in which arguments are constructed, the way in which evidence and data are provided to answer such questions depend on such considerations. Any theory is intimately and ultimately dependent on its paradigmatic and metatheoretical assumptions and presuppositions. These assumptions and presuppositions are often implicit and taken for granted by researchers.

Recent scientific developments suggest that these paradigmatic foundations need to be reexamined. Emerging perspectives in the natural and physical sciences suggest not that the dominant Newtonian/Darwinian paradigm is necessarily "wrong" or "incorrect," but that it may represent only a partial or incomplete picture of "reality." The complexity sciences can be thus seen, not as an alternative to or replacement of, but as an extension of the dominant paradigm. These new sciences call into question the traditional scientific commitment to prediction and certainty (Kiel and Elliott, 1996) that underlies most of social research. It is in this area that the complexity sciences may have the most relevance for social researchers. Implications derived from the complexity sciences address the criticisms of those who view the organizational sciences as dominated by a monolithic paradigmatic structure while simultaneously addressing the need for a synthesis and integration (or at least a *rapprochement*) between competing paradigmatic approaches. Such issues are considered in Chapters 4, 5 and 6. Because of the crucial link between metatheory and theory, and because of the novel implications of the complexity sciences at the *metatheoretical level*, such a consideration is inescapable in efforts to integrate the complexity approach at the *theoretical level*.

Conclusions

The research objective pursued here is the development of an analytical model of the processes and mechanisms of organizational change. With this objective in mind, Chapter 2 developed the critical issues that must be addressed in a theoretical treatment of organizational dynamics, the limitations of contemporary approaches and discussed the relationship between theory and metatheory. Insights and implications deriving from the complexity sciences promise to enhance and extend the understanding of dynamic processes in social organizations, overcome the limitations of contemporary approaches, and offer a resolution to many of the metatheoretical and paradigmatic issues.

The logic of the arguments present to this point can be inferred from Figure 2.1. The lower portion of the figure suggests that the primary purpose of management and managerial studies is to learn and understand how to enhance organizational behaviors. That is, the purpose is to increase the efficiency and effectiveness of organizational functioning. This, in turn, assumes some ability to predict and control organizational outcomes. Organizational changes are induced or experienced with some expectation that a particular action or activity will produce some (not totally unexpected) response (i.e., the response can be predicted). This presumes an understanding of how and why the organizational system will react to an applied or experienced stimulus. This allows for a measure of control over organizational outcomes. This understanding is predicated on a theory of organizational dynamics (i.e., the processes and mechanisms of change) that incorporate the eight elements listed in the middle of the far right column. These elements (i.e., content, history, context, etc.) provide the basis of a (perhaps implicit) theory of the processes and mechanisms of organizational dynamics. However the manner in which these theoretical elements are linked and combined rest on underlying paradigmatic and metatheoretical assumptions (i.e., ontology, epistemology, etc.) that link the subjective features of reality to the objective, and micro-level to macro-level phenomena. Assumptions at the level of metatheory determine, to a large degree, views on the expectations and goals of social science research efforts. These expectations can be characterized as either interpretative understanding (*Verstehen*) or explanation in the natural scientific sense of nomothetic, causal explanation (*Erklären*).[5] The researcher's position on the ultimate goals of social research (*Verstehen* versus *Erklären*) fundamentally affect views on the potential for predicting and controlling organizational and social outcomes. The

[5]These issues (*Erklären* versus *Verstehen*) will be considered in Chapter 6.

promise of the complexity sciences is that they offer the potential to provide a unifying framework that encompasses each of the elements, issues and levels.

To fulfill this promise, an initial concern is to examine the general scope of the complexity sciences and to place specific approaches to the study of complex systems within this context. As White *et al.* (1997) note, social scientists often apply models and perspectives developed in the natural and physical sciences without a clear understanding and review of the relevant literature in which they were developed. To that end, Chapter 3 introduces the complexity sciences and proposes a justification for their incorporation into organizational theory. Related research attempting to integrate the complexity sciences into organizational analysis is reviewed.

That the complexity sciences, in final analysis, are an attempt to understand the dynamic behaviors of physical and natural systems suggests that a critical examination of the emerging approaches – and an effort to integrate their findings and implications into the social sciences – may prove beneficial to organizational researchers.

CHAPTER 3

EMERGING PERSPECTIVES

Traditional and contemporary approaches to the explanation of the processes and mechanisms of organizational change are limited and have proven unsatisfactory in guiding both research efforts and applied management practices. The general proposition forwarded is that these limitations might be ameliorated through incorporation, at a theoretical level, of the implications of the *complexity sciences*. The complexity sciences are an historically recent collection of approaches developed in the natural and physical sciences which focus on generating explanations of the developmental and transformational behaviors of physical and biological systems. As such, the approaches appear to be well suited to enhance efforts to address the areas of controversy, paradox and equivocality outlined in Chapter 2. Because of this, a growing number of researchers and research projects are beginning to incorporate arguments from the complexity sciences to analyses of organizational phenomena.

However, the complexity sciences have yet to be adequately defined even in the physical and natural sciences where they were originally developed (Kauffman, 1991; see also, Horgan, 1995). This lack of a clear sense of a science of complexity and what it may imply for research efforts is even more apparent in the social and organizational sciences. For this reason, and the fact that the complexity sciences are still relatively new[1] to organizational researchers, it is necessary to provide an overview of the various approaches to complexity. The definition of complexity forwarded by Coveney and Highfield (1995) is offered as a provisional point of departure:

> ...complexity is a watchword for a new way of thinking about the *collective* behavior of many basic but interacting units...*complexity is the study of the behavior of macroscopic collections of such units that are endowed with the potential to evolve in time* (Coveney and Highfield, 1995: 7).

It is in this sense that some researchers refer to the complexity sciences as the study of complex adaptive networks or complex adaptive systems (Stacey, 1996a). The central notion expressed in this definition is that of change, evolution, adaptive, and emergent behaviors. The complexity approach offers a fundamentally new way of conceptualizing many of the apparent paradoxes confronting organizational theory and analysis when analyzing the processes of social change. Moreover, a central contention of the complexity approach is that "traditional" reductionist methodologies as employed in much of the management and organizational literature are particularly ill suited to explain these types of behaviors.

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[1]Chaos theory has recently become a topic of much discussion in several areas (see bibliography). However, chaos theory is only one of the approaches to the study of complex systems.

This chapter serves three main purposes: *first*, to provide an introduction and overview of the complexity sciences; *second*, to provide a justification and rationale for their inclusion into the organizational sciences; *third*, to review the current organizational literature that utilizes and applies concepts and implications from the complexity sciences to organizational phenomena.

The Complexity Sciences

Over the past two decades, several new perspectives have emerged in the physical and natural sciences (Figure 3.1). Nonlinear dynamic systems theory, nonequilibrium thermodynamics, dissipative structures, the theory of self-organization, catastrophe theory, the theory of self-organized criticality, antichaos, and chaos theory (collectively referred to as the *complexity sciences*) all purport to offer fresh perspectives on the central problems in the specific domain from which they emerge. Of particular interest in this research project are five[2] of the more distinctive approaches to the study of complex systems:

- Dissipative structures
- Catastrophe theory
- Chaos theory
- Self-organization
- Self-organized criticality

Elements of these approaches are becoming subsumed in an integrative approach referred to as the study of *complex adaptive systems* (CAS).

[2]These are not the only approaches or perspectives that could be subsumed under the complexity label. However, the five approaches considered in this research have received the most attention in the organizational literature and appear to encompass the elements having the most significance to the purposes pursued in this project.

Depending on the particular discipline, the specific problems addressed, and the individual researcher's background, the complexity sciences have been characterized as constituting everything from a major paradigm shift which challenges established scientific orthodoxy to an extension and refinement of existing theory.[3]

Insights from these emerging perspectives have implications that merit careful consideration for developments and extensions of existing work at the metatheoretical, theoretical and methodological levels in organizational theory. The primary focus here is not on the development of new or novel insights about complex system behaviors. The primary task is to consider the insights as developed by complexity researchers and begin the task of *integrating* these insights into organizational theory and analysis. Issues and implications arising from the complexity sciences are relevant to the relationship between various paradigmatic approaches, to explanations and theories about how organizations change and develop over time, and to the possibility of predicting and controlling those changes.

Chaos and catastrophe theories, in particular, have been introduced into the organizational sciences, mainly as methodological tools for use in the empirical analysis of data. It is undoubtedly true that these approaches to

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[3]Part of the difficulty with the complexity science literature (and the partial cause of many of the conflicting claims) is that the emerging literature ranges between two extremes: from the highly technical and quantitative to that with a highly mystical and metaphysical bent. One of the subsidiary objectives here is to make the subject matter more accessible to organizational researchers with a predilection toward neither approach.

nonlinear modeling offer the potential for a fuller and more complete understanding and explication of the complexities of social and organizational phenomena.[4] While traditional and well-known linear-based methods and models have proven useful in the analysis of social data, as Brown (1995: 1) notes, "...there is no apparent reason, intuitive or otherwise, as to why human behavior should be more linear than the behavior of other things, living and nonliving."

Nonlinear methods have been utilized in the physical and biological sciences to develop a new understanding, and provide new and potentially fruitful avenues of research. It should come as no surprise that developments in these areas (i.e., physics, biology, mathematics, etc.) should encourage efforts in the social sciences to examine the potential for nonlinearities in organizational settings and in the modeling of social system behaviors. However, the methodological implications of the complexity sciences provide only a point of departure. The true value of the approaches may lie in a reconceptualization of social science processes and approaches to the study of such processes. If, as De Greene (1996) suggests, the new approaches

> ...act as perturbations and fluctuations, driving a restructuring of social science, and if they help generate new paradigm thinking, then the future can indeed be promising. If, however, the new theories function just as new tools (like a new form of regression analysis), then the social

[4]There is some resistance to the use of nonlinear models in social science research. For example, at a recent workshop a model was proposed that included a nonlinear relationship among variables. A comment was made, to the effect, of "why complicate things for yourself. Could there not be a moderator, or mediating variable, that would simplify (i.e., linearize) the problem?"

> sciences may find that the exciting and challenging aspects of social reality have been usurped by the more dynamic, the more imaginative, and the more adventuresome, and that traditional economics, sociology, political science, and so on have become increasingly irrelevant (De Greene, 1996: 292).

Beyond Methodology

Though the application of nonlinear methods to the empirical modeling of social phenomena is an important area of inquiry, there is more significance to the study of complex, chaotic and catastrophic system behaviors than their methodological and empirical implications. Restriction of these approaches to their potential as methodological tools, without a thorough assessment, analysis and incorporation at metatheoretical and theoretical levels, seems premature. After all, models of system behavior are just that – reduced-form representations of "real-world" behaviors. All to often, scientists (social and otherwise) commit what Morrison (1991: 270) refers to as the "fallacy...of confusing the model with reality. This has happened again and again in the history of science and mathematics." While many insights may be gained from modeling strategies, of at least equal importance should be attached to the theoretical and metatheoretical underpinnings upon which such models are based. Theoretical and substantive implications of nonlinear dynamics have begun to be suggested in the organizational literature, but not yet fully explored.

The complexity sciences call into question many of the basic principles and tenets upon which traditional scientific inquiry (and, thus, most of mainstream social and organizational theory) is based (see, for example, Kiel and Elliott, 1996). Some researchers interested in the emerging perspectives suggest that these approaches imply a shift or major reorientation in thinking so profound as to constitute a paradigm shift (e.g., Csányi and Kampis, 1987; Mandelbrot, 1987). Organizational researchers of this opinion suggest an immediate and all-encompassing incorporation of the complexity sciences into organizational analysis in order to overcome many of the problems besetting the field. Though the complexity sciences *have* begun to appear in the social science literature, not all organizational scientists are so enthusiastic in their appraisal of its implications. For example, Johnson and Burton (1994: 320) profess reservations as to the significance of these developments and suggest that "...chaos theory as it now stands cannot be applied rigorously to the study of social systems" and further, that "...the more metaphorical use of complexity theory is also problematic."

Following Begun (1994), the fundamental premise of this project is that attempts at empirical *application* of complexity insights to organizational behaviors are premature, certainly at the level of normative prescription. In addition, efforts to empirically demonstrate the effects of complex phenomena are in their infancy because the tools are not well-developed nor are the tools that are available accessible or familiar to most organizational researchers. Moreover, we suggest that these perspectives need to be better integrated at a theoretical level ***before*** engaging in an empirical research program. The development of empirical tools or the demonstration of chaotic, complex phenomena is, thus, not the focus. Neither is the task to derive implications for the practicing manager nor to develop prescriptive, normative statements to guide organizational decision makers. The task at hand is to examine the issues and implications arising from the complexity sciences at the metatheoretical and theoretical levels. Once the insights are integrated and explicated at these points, researchers may be in a position to examine and to apply the concepts at the empirical and applied levels.

Multiple Approaches to Complexity

Chaos and catastrophe theories are but two of the approaches to the study of the broader phenomena of complex, dynamic systems. Other approaches are also intimately concerned with attempts to describe and understand the behavior of complex systems. As these various approaches (generically and collectively referred to as the *complexity sciences*) are relatively new and have developed in different disciplines, their relationship to one another is not generally understood nor fully appreciated. Moreover, their potential applicability to the social sciences only dimly perceived. What seems apparent, however, is that an *interdisciplinary* field of study[5] combining insights

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[5]The Santa Fe Institute (SFI), located in Santa Fe NM, is a "...multidisciplinary graduate research and teaching institute formed to nurture research on complex systems and their simpler elements." SFI publishes a series devoted to the study of complex systems, the Santa Fe Institute Studies in the Sciences of Complexity. The New England Complex Systems Institute (NECSI) is an interdisciplinary educational and research institute that promotes the study of complex systems. NECSI is a "...joint effort of faculty of New England academic institutions for the advancement of communication and collaboration outside of institutional and departmental boundaries."

gained from each of the approaches to complexity discussed in this research is emerging.

Though no general theoretical approach has succeeded in integrating the perspectives (van de Vliet, 1994; Kauffman, 1991), a unifying theme is a focus on systemic change, an attempt to understand the temporal behaviors of both spatially simple and complex systems. Beyond this admittedly broad area of convergent interest, however, much variation and uncertainty is attached to the usage of these perspectives. In addition to problems associated with content and terminology specific to the particular discipline from which each of the perspectives emerged, differences in the *type* of change under examination accounts for much of the confusion and difficulty in definition. Systemic change (as suggested earlier) may be either gradual, incremental, and evolutionary or sudden, discontinuous, and revolutionary. Unfortunately, theoretical approaches utilized by organizational researchers often tend to emphasize either one or the other mode of change (e.g., evolutionary versus revolutionary change) as the sole explanation of the observed dynamics, resulting in an "either/or fallacy" (Kauffman and Oliva, 1994: 207). The complexity sciences attempt to overcome this (possible) fallacy by focusing on the interplay between gradual and sudden changes in organizational and system trajectories. Thus, complex systems have both temporal and spatial dimensions. The complexity sciences emphasize the importance of temporality, which has often been ignored in organizational research. It is this *interaction* between spatial and temporal characteristics that have significant effects for the system's trajectory (see, for example, Wilkinson, 1990).

Though there are multiple approaches to the study of complex systems, consideration is limited to the five relatively well-defined perspectives noted above. The elements and implications of these approaches will be examined in greater depth in Chapter 5, where they are contrasted to the implications derived from the Newtonian/Darwinian paradigm. Here, a brief introduction to each is provided (Table 3.1).

Dissipative Structures

Developed initially through the study of the behavior of chemical systems (Prigogine *et al.*, 1972a, 1972b),[6] the field of nonequilibrium thermodynamics focuses on systems in states of extreme instability. Such instabilities offer the potential for self-organizing and self-maintaining behaviors. The behaviors of systems that (1) enter a sufficiently nonequilibrium state, (2) have many degrees of freedom, and (3) are open to the inflow of energy, information and/or matter (i.e., *dissipative structures*) appear to cast doubt on the general validity of the second law of thermodynamics where systems attain a state of maximum equilibrium characterized by decreasing activity and entropy production. Rather, dissipative structures (i.e., those characterized by high states of energy exchange with the environment) are typified by instabilities that lead the system

[6]Prigogine was awarded a Nobel Prize in 1977 for his work on dissipative structures.

through a sequence of transitions or fluctuations at periodic *bifurcation points*. At these transition points, the system moves to a new state corresponding to a new (and potentially higher) state of complexity that is not only quantitatively but also qualitatively different from the previous state.

The point emphasized here is that nonequilibrium thermodynamics and dissipative structures suggest the possibility that physical systems exhibit self-organizing behaviors through the principle of "order through fluctuation" (Jantsch, 1975, 1980). The key to understanding morphogenic and transformational change lies in understanding the dissipative process through which new structural arrangements emerge from the interplay between system and environment, order and disorder. System instabilities are not inherently negative; indeed, from the dissipative structures perspective instability may be a necessary prerequisite for system change and development. It is only through such episodes of transformational change at the point of bifurcation that the limitations of developmental change are overcome.

Catastrophe Theory

Similar to the dissipative structures approach, discontinuities and revolutionary change in system behavior is the focus of catastrophe theory. Catastrophe theory attempts to mathematically describe discontinuous system behaviors resulting from continuous stimuli (Gregory-Allen and Henderson, 1991). More so than the dissipative approach, however, catastrophe theory is an approach to the modeling of such behaviors (Thom, 1975; Zeeman, 1976; Oliva, 1991; Oliva *et al.*, 1992; Vendrik, 1993; Kauffman and Oliva, 1994).

Descriptions of system behaviors have traditionally been modeled by use of differential equations. However, as a descriptive language of system behavior, differential equations have an inherent limitation: they can describe only those phenomena where change is smooth and continuous (Thom, 1975). Zeeman (1976) notes:

> In mathematical terms, the solutions to a differential equation must be functions that are differentiable. Relatively few phenomena are that orderly and well behaved; on the contrary, the world is full of sudden transformations and unpredictable divergences, which call for functions that are not differentiable (Zeeman, 1976: 65).

Catastrophe theory takes issue with traditional research efforts and methods that assume gradual, incremental and evolutionary change as the norm for system dynamics. Catastrophe phenomena are the result of dynamic processes that lead to sudden changes in at least one variable within the context of relatively small changes in other variables or parameters (Brown, 1995). Catastrophe theory was developed as a mathematical modeling methodology to be applied in situations where gradual and continuous forces or pressures lead to abrupt, discontinuous or divergent changes in system behaviors. Thus, it is a formal system which mathematically locates these points of equilibrium breakdown (i.e., bifurcations) in terms of polynomial representations of seven "elementary catastrophes" (Tabor, 1989).

In its original formulation by Thom, catastrophe theory states that "...if a process is determined by minimizing or maximizing some function, and if it is controlled by no more than four factors, then any singularity of the resulting behavior surface must be similar to one of the seven catastrophes" (Zeeman, 1976: 80). However, Thom's early work has been further generalized and is no longer bound by polynomial representation of such models (Brown, 1995).

Chaos Theory

Chaos theory, at its most elementary level, is an attempt to understand the seemingly random behavior exhibited by a simple deterministic system consisting of only a few variables or interacting components. Chaotic phenomena are, thus, a class of deterministic phenomena that appear random or stochastic. The focus in chaos research is on answering a seemingly paradoxical question: 'How can a deterministic system, governed by fixed rules that do not themselves involve any elements of chance, generate such random appearing behavior?' (Crutchfield *et al.*, 1985; Butler, 1989; Hansson, 1991). Though the possibility for chaos-like phenomena had been suggested earlier, the term "chaos" gained broad recognition by the scientific community with the analysis by Li and Yorke (1975) and gained public currency with Gleick's (1987) popular work.

Deterministic chaos is defined as "...aperiodic bounded dynamics in a deterministic system with sensitive dependence on initial conditions" (Kaplan and Glass, 1995: 27). Chaos theory is developed in more detail later but a brief description of the four concepts expressed in this definition seems warranted at this point. First, *aperiodic* refers to the fact that a system state is never repeated. This lack of periodicity implies a lack of predictability in truly chaotic systems and belies the underlying determinism that generates the seemingly random behavior that is exhibited. Second, though the behavior of the system is aperiodic, it is *bounded* such that on successive iterations the system remains within a finite range, never exploding into unconstrained growth. Third, *deterministic* means that temporal dynamics and spatial interactions are regulated by definite rules (i.e., mathematical relationships) which include no random or stochastic terms. Finally, *sensitive dependence on initial conditions* suggests that systems that have very close initial starting points will diverge as time proceeds. This sensitivity to initial conditions, an essential aspect of chaotic systems, implies that without infinite precision in the measurement of initial conditions of system parameters, long-term predictability may be (not only practically but also) theoretically impossible.

Nonlinear systems may exhibit either *low-dimensional* or *high-dimensional* chaos. Low-dimensional chaos may allow for some short-term prediction, but high-dimensional chaos exhibits such variability and variation to preclude any efforts at prediction and control (Kiel and Elliott, 1996). These mathematical properties have been studied extensively and normally illustrated through the use of a first-order nonlinear difference equation, but their implications and applications to social systems are unclear. However, at least one implication is usually suggested: the unpredictable behaviors exhibited by these simple mathematical exercises call into question the possibility of the prediction and control of social system outcomes. The question remains as to the limits of that predictability and control: do low- or high-dimensional chaotic processes characterize social systems?

Self-Organized Criticality

While the dissipative structures, catastrophe and chaos perspectives all focus on providing explanations for system discontinuities and radical transformation, self-organized criticality (Bak and Chen, 1991; Kadanoff, 1991; Bak, Tang and Wiesenfeld, 1988; Carlson *et al.*, 1993; Ruthen, 1993) is driven by a related, but somewhat different question: Why and how, given the potential for radical discontinuities in system behaviors, do some systems seem to evolve away from the extremes of complete order, inertia and stasis on the one hand and complete randomness and chaos on the other? Self-organized criticality (SOC) suggests that many systems naturally evolve to a critical state poised between order and disorder, and that the mechanisms or principles governing this self-organizing behavior are discoverable and widely occurring in many natural and physical systems. Thus the research agenda for SOC is to

> ...demonstrate numerically that dynamical systems with extended spatial degrees of freedom in two or three dimensions naturally evolve into self-organized critical states. By self-organized we mean that the system naturally evolves to the state without detailed specifications of the initial conditions (i.e., the critical state is an attractor of the system) (Bak *et al.* 1988: 356).

This highlights an important distinction between SOC and chaos theory. In chaotic systems, a small initial uncertainty grows exponentially with time. Furthermore, as attempts are make to predict further and further into the future, the amount of information needed about the initial state of the system increases exponentially with time (i.e., the system exhibits sensitivity to initial conditions). For the most part, this exponential growth prevents long-term prediction. Through simulation studies, SOC suggests that for self-organized critical systems, uncertainty increases more slowly than it does for chaotic systems. The uncertainty increases according to a *power law* rather than an *exponential law*. This behavior, termed *weak chaos*, is a result of self-organized criticality (Bak and Chen, 1991).

Weak, or low-dimensional, chaos differs significantly from fully chaotic behavior. A time scale beyond which it is impossible to make predictions characterizes fully chaotic systems. Weakly chaotic systems lack such a time scale and so allow for, at least, mid-term predictions. Bak and Chen (1991) suggest that because they find that all self-organized critical systems are weakly chaotic, it is to be expected that weak chaos is very common in nature. To the extent that social systems are governed by the same, or similar, processes as self-organized critical systems, at least some measure of predictability and control may be possible.

Self-Organization

Developed by biologist Stuart Kauffman (1991, 1993, 1995) as a reaction to the dominance of Darwinian evolutionary processes in biology, the self-organizing approach[7] is, in many senses, the complement or mirror image of chaos theory (Briggs and Peat, 1989; Kauffman, 1991; Leifer, 1989; Lewin, 1993; Stewart, 1993). Chaos theory is an approach to the study of spatially simple systems that are governed by deterministic rules but produce complex and complicated temporal behaviors. Alternatively, the self-organizing approach concerns the study of how systems that are spatially complex and have the potential for chaos generate organized and patterned temporal behaviors. As Stewart (1993) states:

> As opposed to chaos theory which is the generation of disorganized behavior from simplicity, complexity involves the development of an organized complex system from a random group with simple rules (Stewart, 1993: 2).

As such, complexity theory/self-organization is closely related to self-organized criticality. In fact, Bak and Chen (1991: 53) suggest that "...the theory of complexity and the theory of self-organized criticality may generically be one and the same thing."

[7]The term complexity theory is often used to characterize Kauffman's body of work. In the interests of continuity, that practice will be followed and "complexity theory," where used, can be read as synonymous with our characterization of Kauffman's work as the "self-organizing approach." The use of "complexity sciences" is reserved to refer to the spectrum of theoretical approaches to the study of complex systems.

Self-organizing theory is an attempt to understand how spatially complex systems with many randomly interacting components produce complex, but organized and patterned behaviors and to explain the apparent paradox how organized large-scale structures function when their constituent elements are "swimming in a sea of chaos" (Ruthen, 1993). Further, self-organization is viewed as "...the capacity of open and living systems, such as we live in and we ourselves are, to generate their own new forms from inner guidelines rather than the imposition of form from outside" (Loye and Eisler, 1987: 56).

Kauffman refers to the phenomenon of self-organization as *antichaos* and views self-organization as a reaction to Darwinian evolutionary processes, which place the motive force for evolution in selection processes operating at an environmental level. Self-organization suggests that

> ...some very disordered systems spontaneously 'crystallize' into a high degree of order. Antichaos plays an important part in biological development and evolution...Since Darwin, biologists have seen natural selection as virtually the sole source of that order <in biological systems>...But Darwin could not have suspected the existence of self-organization, a recently discovered, innate property of some complex systems...Selection has molded, but was not compelled to invent, the native coherence of ontogeny, or biological development...We may have begun to understand evolution as the marriage of selection and self-organization (Kauffman, 1991: 78).

It is the *interaction* between external selection mechanisms and internally generated self-organization that is important in explaining system evolution and development. Being "ordered" is not logically equivalent to being adaptive, so that self-organizing mechanisms for generating order are not *alternatives* to selection mechanisms but rather that both are necessary for an adequate explanation of developmental and evolutionary phenomena (Reeve and Sherman, 1993). Similar to the dissipative structures approach, the self-organizing approach suggests that the system and its environment are inextricably intertwined and that both internal and external factors must be considered in attempting to understand system change and transformation. Moreover, the relationship between order and disorder is critical. The system must not exhibit so much order as to fall into the "trap" of inertia and stasis, but must also guard against extremes of disorder and chaos. Successful systems are those

> ...at the transition between order and chaos. A central tenet of complexity theory is that selection or learning drives systems towards this edge of chaos. Systems that are too simple do not survive in a competitive environment because more sophisticated systems can outwit them by exploiting their regularities. But systems that are too random do not survive either. It pays in survival terms to be as complicated as possible, without becoming totally structureless (Stewart, 1993: 3).

Further, it is at this transition point between order and disorder (i.e., at the edge of chaos) where new structural arrangements and morphogenic changes are most likely to emerge.

Simple Complexity or Complex Simplicity?

This brief discussion of the selected approaches to complexity serves only to highlight the diversity of problems, perspectives and concerns that fall under the general rubric of the "complexity sciences." It does, however, indicate the general explanatory problem for a "science of complexity" – to define and to characterize for diverse instances and phenomenal domains the interactions between the simple and complex. Phased differently, the study of complex systems seeks to explain how the simple produces the complex and, conversely, how the complex results in the simple (O'Connor, 1994). Each of the specific approaches will be discussed in detail in Chapter 5. The discussion in Chapters 4 and 5 will provide the foundation for the discussion of CAS that forms the basis for the analytic model of system dynamics presented in Chapter 7. At this point, the purpose is only to provide a brief introduction to each as they are increasingly referenced in the organizational and managerial literatures. The immediate question of interest is "why" these perspectives have increased in salience for many organizational theorists, researchers and practitioners.

Why Study Complexity?

A recent survey of members of the Organization Development and Change (OD&C) division of the Academy of Management was conducted in order to specify a "common body of knowledge" for masters-level OD&C programs. The preliminary report (Worley and Varney, 1998) argues that, in terms of system dynamics, the core knowledge of OD&C should include

> ...the description and understanding of how systems evolve and develop over time...<and an> understanding of how systems respond to exogenous and endogenous disruption as well as planned interventions (e.g., evolution and revolution, punctuated equilibrium theory, chaos theory, catastrophe theory, incremental vs. quantum change, transformation theory, etc.). (Worley and Varney, 1998: 10).

Though all of the specific approaches to complexity considered in this research are not mentioned in the report (and some are mentioned in the report are not considered here), it seems clear that these represent facets of the complexity sciences.

Why the interest in the complexity sciences? Do the complexity sciences suggest (as many assert) a paradigm shift, an entirely new way of looking at organizational phenomena, or can they best be seen as an extension of general systems theory (Crutchfield *et al.*, 1985; Loye and Eisler, 1987: 55; Levy, 1994: 169)? Or is the interest in chaotic and self-organizing phenomena simply an example of social scientists rushing headlong to embrace a new perspective because of its popularity and currency in the "hard" sciences? Many view the interest in chaos and complexity as an example of "bandwagon science," with social scientists embracing a new perspective solely because of the apparent legitimacy which entails from an association with the "hard" sciences, and caution that "...a little physics is a dangerous thing, indeed" (Mirowski, 1990: 300). Others take a somewhat more middle-of-the-road approach and agree that the emerging perspectives *may* have profound implications, but that these implications face many barriers to integration into the social sciences and that years may be required for the diffusion and inclusion of complexity-based theories into organizational analysis (e.g., Begun, 1994). This section suggests five reasons that give "face validity" to the incorporation of complexity research into organizational studies (Table 3.2).

Increasing Rates of Change

First, increasing environmental complexity and rates of change have been well-noted, and commented on, in recent years. Not only do tangible factors in the environment (e.g., products, processes, competitors, etc.) seem to be changing at an increasing rate, the rules that seem to govern organizational success appear to be changing (Hodgetts *et al.*, 1994). Much of the recent popular, practitioner-oriented management literature has made note of increasing rates of change in the organizational environment and the need for management to deal with its ramifications (e.g., Peters, 1987; Naisbitt, 1984; Naisbitt & Aburdene, 1985; Huey, 1994). Much of this popular literature is firmly embedded in the management choice perspective (Child, 1972) and, after some discussion of the nature and implications of continual and increasing environmental change and uncertainty, tends to issue prescriptive pronouncements to management for the development of methods to achieve "transformational" change or leadership, to become more "flexible," to "reinvent the corporation," etc. The general theme is that change has become an increasingly salient feature of organizational life and it is management's job to deal with these changing circumstances.[8] Little attention is given to the theoretical (as opposed to practical) source of such complex behavior.

[8]Most of this literature sees organizational development as a process of induced, designed change as opposed to change as a result of emergent processes. See Mintzberg (1990, 1991) and Ansoff (1991) for a discussion of the issues involved in the designed versus emergent debate.

One of the more significant substantive implications of chaos theory is that dynamic, nonlinear systems may exhibit surprising and counterintuitive behavior, making prediction and control (and possibly management as it is popularly conceived) problematic. Cartwright (1991) notes that one implication for planners is that even if the "rules of the game" are completely known and understood at the local level, it may be impossible to predict global results. This lack of predictability "...is inherent rather than situational...<and> planning based on prediction is not merely impractical in some cases; it is logically impossible" (Cartwright, 1991: 45). On the hand, implications from SOC suggest that some types of systems exhibit low-dimensional (or weak) chaos and that prediction, at least in the short-term, may be possible. In either event, the implication is that planning methods and processes must take these issues into account and that all systems may be subject to sudden discontinuities.

Sudden discontinuities in social system behaviors may, in fact, be examples of change resulting from chaotic processes and all social systems, even those with an appearance of stability, have the *potential* for chaotic behavior. Moreover, such discontinuities may be required – to the extent that social organizations can be characterized as examples of dissipative structures – for organizational "success." Shifts in organizational policy, crisis behavior, negotiation processes, downsizing, organizational decline, product discontinuations, voluntary employee turnover, management succession, among others, have been suggested as potential organizational examples of chaotic behavior. Gordon reinforces this argument by noting that

> ...some social systems appear to behave in a chaotic manner, that is: (1) they can exhibit random-appearing and nonrepeating behaviors; (2) they can show the same characteristics 'roughness' at essentially any scale (that is, they exhibit fractal qualities) – for example, stock market patterns plotted on a scale of months, weeks, days, or minutes look about as rough as a plot on a scale of many years; (3) they may be exceedingly hard to forecast with conventional methods (Gordon, 1992: 2).

At a substantive/practical level, then, the complexity sciences may represent a perspective that will lead to a better understanding of the behaviors of social and organizational systems as they are faced with increasing amounts of internal and external uncertainty.

Increasing Emphasis on Process Research

A second reason for the potential applicability of complexity research is that complexity sciences represent an approach to the study of dynamic systems and the processes that lead to that dynamic behavior. While much of the research into complex systems began with an examination of physical and natural systems, processes in economic systems can similarly be characterized. That is, social processes can also be characterized as having (1) dynamic nonlinear relationships among a multitude of components, (2) complex, recursive, or highly iterative interactions among components, and that (3) systems with these characteristics may have potential to evolve dynamically over time (Levy, 1994; Radzicki, 1990; Butler, 1990). Systems or descriptions of systems (i.e., models) having these characteristics will often exhibit chaotic and, potentially, self-organizing behavior over at least some part of their domain.

The intuition that social systems appear to exhibit many of the requirements for chaotic (and complex) temporal behaviors is a driving force in much of the current research. The complexity approach is consistent with the increasing emphasis in the organizational sciences on process research and organizational dynamics (e.g., Ranson, Hinings and Greenwood, 1980; Fombrun, 1986; Pettigrew, 1985, 1987; Greenwood and Hinings, 1987; Hinings and Greenwood, 1988; Quinn and Cameron, 1988; Van de Ven and Huber, 1990; Monge, 1990; Kelly and Amburgey, 1991; Van de Ven, 1992; Chakravarthy and Doz, 1992; Hart, 1992; Mintzberg and Westley, 1992; Dubinskas, 1994; Hurst and Zimmerman, 1994; Tushman and Romanelli, 1994; Lichtenstein, 1995; Slater, 1995; Stacey, 1995, 1996; Rajagopalan and Spreitzer, 1997). At an intuitive level, because the complexity sciences are specifically and fundamentally concerned with efforts to explain dynamical system behaviors and processes, they appear to hold promise for a better understanding of organizational processes.

Instability and unpredictability appear to be inherent to the social world and cause and effect relationships often seem to be inextricably intertwined. To the extent that the complexity sciences can help to explain, explicate and illustrate dynamic processes in natural and physical systems, they offer the potential for a better understanding of similar processes occurring in social systems.

Similarity to Existing Models of Social Behavior

Third, as related to modeling strategies, the mathematical models that produce chaotic behavior in biology and physics are similar to some of the models already used in the study of social behaviors.[9] Further, benefit may be derived by incorporating nonlinearities into more traditional, established research programs. For example, Gregersen and Sailer (1993: 781) note that "...much of the network literature, especially the work on dynamic networks" may prove amenable to complexity analysis. Such incorporation would allow for the exploration of some of the more significant implications arising from the complexity sciences. For example, the source of chaotic behavior may be endogenous to the system not merely a result of exogenous (i.e., environmental) shocks to a system in a state of equilibrium. In addition, evolutionary "progress" is perhaps closely related to the *potential* for chaos and revolutionary change (i.e., systems evolve to the edge of chaos – the border between stability and disorder).

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[9]E.g., see Andersen and Sturis (1988); May (1976); May and Oster (1976); see also the use of the Lotka-Volterra equations by Hannan and Freeman (1989) and Guckenheimer, Oster, and Ipaktchi (1977) for an examination of the dynamics of density-dependent models of population growth.

Disappointing Results and Lack of Relevance

Fourth, a more substantive argument suggests the significance of the complexity sciences to the social sciences. Previous arguments (Chapter 2) discussed the limitations of organizational theory in adequately contending with issues of organizational change and transformation. These limitations may have much to do with the failures at the applied and practical levels. In terms of OD (organizational development) and managerial interventions, it has been suggested that despite evidence of a "...*tsunami* of change efforts that promise eventual efficiency, effectiveness ...and instant relief...approximately 70% of change efforts have failed to meet expectations."[10] These disappointing results suggest that much of organizational theory has little relevance for practitioners because there is no clear theoretical understanding of organizational change processes.

These "failures" may be even more significant for the social sciences in general. As Ashmos and Huber (1987) argue:

> ...despite over a half century of effort, the study of organizations has produced disappointing results; generally, findings have low explanatory power and seldom are associated with well-defined domains. McKelvey (1982) is correct when he argues that the major reason for this is that the lack of a precise and widely applicable classification scheme impedes

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[10] This quote comes from an announcement for a conference on "Empirically Driven Change" (April 1998) sponsored by the Executive Master of Organization Development program at Bowling Green State University in Bowling Green, Ohio. It is not offered as empirical proof of the relative lack of success of OD&C efforts, but rather is intended to suggest a sense of the feeling of OD&C practitioners and practicing managers.

> the comparison of studies, and thus thwarts the cumulation of knowledge (Ashmos and Huber, 1987: 611).

Daft and Lewin (1990: 1) make a similar point by arguing that although the field of organizational studies "has progressed enormously in new methods and insights" the field has "been a source of recurrent disappointment for practitioners and academics alike." One suggestion to ameliorate the problem (Ashmos and Huber, 1987) is a greater appreciation and application of the classification issues addressed by General System Theory (Ashmos and Huber, 1987; see also Boulding, 1952; Bertalanffy, 1968; Kast and Rosenzweig, 1972; Cummings, 1980) and Living Systems Theory (Miller, 1978). Ashmos and Huber may be correct in noting the lost opportunities of General Systems Theory (GST), but it has been argued that GST offers a relatively static or, at most, equilibrium view of systems.[11] A more useful extension of GST would consist of a generally accepted classification scheme of system characteristics but would also include a theory explaining the dynamics of systemic behavior (i.e., the *processes* of change, both developmental and transformational). Such an extension would integrate both temporal and spatial dimensions of system behaviors. From the complexity perspective, this would entail the incorporation of a disequilibrium perspective in order to extend explanations of system dynamics.

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[11] This argument will be developed and extended in Chapter 4.

As Van de Ven and Huber (1990) suggest, the understanding of temporal sequences (i.e., conducting process research) is fundamental and critical to the development and testing of theories of organizational dynamics. Addressing this issue, for example, Monge (1990) develops an analysis of temporal issues relating to the study of organizational processes. However, this welcome trend toward the analysis of organizational processes and temporal characteristics should not be taken to extremes such that content issues, or spatial characteristics, are neglected. The complexity sciences propose that it is the interplay and interaction between temporal and spatial dimensions that may be of most significance.

More than a lack of a generally accepted classification scheme or lack of a process-orientation, it may be that the poor analytical results (low R^2 values, lack of statistical significance, and problems with replicability) result when analyzing dynamic systems with standard (i.e., linear) statistical techniques. When systems with similar starting points and environments end up having different outcomes, social and organizational researchers customarily conclude that either

1) significant, explanatory variables have been omitted from the study,
2) the measurement instrument is too imprecise and "rough," or that
3) the random or stochastic part of the problem has overwhelmed the patterned part (Gregersen and Sailer, 1993).

To improve the research, much effort is expended to eliminate these three problems in subsequent studies. Instead of trying harder, however, it may be that social researchers need try something different. This something different is the application of nonlinear feedback models, and the insights gained from the complexity sciences, to the examination of social and organizational dynamics.

Metatheoretical and Philosophical Implications

Finally, at a metatheoretical level, the complexity sciences suggest that the sciences may be in the

> ...midst of a profound rupture between older and emergent notions of scientific explanation. The very meanings of order and chaos, the deterministic and the stochastic, are being reconceptualized in this decade, and it is fair to presume that things will never be the same (Mirowski, 1990: 289).

The issues raised by the complexity sciences call into question the foundation upon which much of the scientific effort, as traditionally conceived, is based (Crutchfield *et al.*, 1985). The issues involved at this level underlie the claim that the emerging approaches constitute a "new science" (Gleick, 1987; Wheatley, 1992. In the organization and management theory (OMT) literature, these metatheoretical and philosophical have implications for the ongoing scholarly debate about the lack of paradigm consensus in the field. The complexity sciences suggest a shift in focus from *knowledge exploitation* to *knowledge exploration* for the organizational sciences. As Van de Ven (1998) notes

> ...there are pendulum swings in OMT, as in many other fields, between knowledge exploitation and exploitation (to use Jim March's terms). The vitality of OMT requires continuing additions of research knowledge to its core disciplinary base on the one hand, and ongoing explorations of new views and innovative perspectives on the other hand. Our collective challenges are to achieve some reasonable balance between knowledge exploration and exploitation, and to figure out how to communicate – and thereby integrate – ideas across new and existing perspectives. (Hoang, 1998: 1).

The complexity sciences certainly offer a new perspective for organizational theorists – an opportunity to explore new perspectives in order to advance the state of organization and management theory. The major exploratory task is to develop the implications of the complexity sciences, communicate these insights to organizational researchers and to integrate the perspective into organizational theory. Given the linkages between theory and metatheory, this cannot be accomplished without a consideration of the paradigmatic foundations of the complexity approach and how they differ from the dominant paradigm in which most social researchers work.

Complexity Science in the Organizational Literature

Chaos theory, in particular, has recently begun to receive increased attention in the organizational and administrative sciences[12] (see, for example, Loye and Eisler, 1987; Anderson and Sturis, 1988; Priesmeyer and Batik, 1989; Bygrave, 1989a, 1989b, 1993; Priesmeyer, 1992; Bhargava *et al.*, 1990; Lant and Mezias, 1990; Cartwright, 1991; Hansson, 1991; Gordon, 1991, 1992;

[12] Interest in catastrophe theory in the social sciences predates the interest in chaos theory.

Istvan, 1992; Vinten, 1992; Wheatley, 1992; Gregersen and Sailer, 1993; Kiel, 1993, 1994; Begun, 1994; Dubinskas, 1994; Euster, 1994; Gordon and Greenspan, 1994; Hibbert and Wilkinson, 1994; Levy, 1994; van de Vliet, 1994; Stacey, 1995; Smith, 1995; Thiétart and Forgues, 1995; Cheng and Van de Ven, 1996; Kiel and Elliott, 1996). Gregersen and Sailer (1993), for example, investigate the significance of chaos theory to social science research and note that arguments deriving from chaos theory are "general enough to apply to any type of entity, including individuals, groups, and organizations, and therefore are relevant to a large domain of social science problems" (Gregersen and Sailer, 1993: 777). In a more specific domain, Hibbert and Wilkinson (1994) suggest that chaos theory can improve the understanding of the complex dynamics of marketing systems. Chaos theory "...offers an alternative explanation for the existence of various types of marketing institutions...and leads to new ways of predicting structural change and evolution" (Hibbert and Wilkinson, 1994: 219).

In the area of productivity research, Istvan (1992: 525) suggests that "...a decade of observed large differences in productivity driven competitive advantage cannot be explained by traditional productivity notions or conventional strategic analysis." He further suggests that "...large competitive differences appear to arise from a new productivity source, nonlinear systems dynamics in business organizations." Similarly, the areas of social forecasting (Hansson, 1991; Bhargava, *et al.*, 1990), planning (Cartwright, 1991), creativity and leadership (Wheatley, 1992; Vinten, 1992; Stacey, 1995, 1996a), entrepreneurship (Bygrave, 1989a, 1989b, 1993) and strategic management and policy making (Levy, 1994; Kiel, 1993 & 1994; Gordon, 1992; Stacey, 1996b) have begun to be analyzed in light of the tenets of chaos theory. Levy (1994: 167), in particular, contends that "...chaos theory provides a useful theoretical framework for understanding the dynamic evolution of industries and the complex interaction among industry actors." Thus, in the very recent past, subjects of interest to organizational theorist, observer, and practitioner alike have begun to be analyzed in light of the findings and from the perspective of the complexity sciences.

Quantitative applications in sociology (e.g., Baker, 1993; Johnsson, 1993; Leydesdorff, 1993), psychology (e.g., Barton, 1994; Krippner, 1994; Halasz, 1995; Mandel, 1995) and organizational theory have not been as prevalent as in economics (e.g., Boldrin and Deneckere, 1990; Ng and Young, 1990; Day and Pianigiana, 1991; Eliasson, 1991; Hsieh, 1991; Invernizzi and Medio, 1991; Rosser, 1991; Young, Ng and Parker, 1991; Bullard and Butler, 1993; Bala and Kiefer, 1994; Hommes, Nusse and Simonovits, 1995) and political science (e.g., Saperstein and Mayer-Kress, 1988; Saperstein, 1991, 1996; Wolfson, Puri and Martelli, 1992; Brown, 1996). Applications in the organizational literature have tended toward more metaphorical, analogical and postmodernist[13] or poststructuralist usage (Young, 1991; Kiel and Elliott, 1996)

[13]See Sardar (1994) on complexity science as a postmodern reaction to traditional science

though quantitative applications have begun to appear. For example, Cheng and Van de Ven (1996) empirically demonstrate chaotic behavior in the innovation process.

Catastrophe theory has received some empirical attention, especially by Oliva and co-researchers (1988, 1991, 1992, 1994; see also, Rummel, 1987; Gregory-Allen and Henderson, 1991; Baack and Cullen, 1994). The dissipative structures perspective has been applied to historical analysis (Artigiani, 1987), organizational transformation (Gemmill and Smith, 1985; Smith, 1986; Leifer, 1989) and small group behavior (Smith and Comer, 1994). The self-organizing approach has also begun to appear in the organizational literature (e.g., Funtowicz and Ravetz, 1994).

Conclusions

The chapters in Part I argue that change and transformation are areas of critical concern to organizational theory and analysis but that there is a limited understanding of the fundamental mechanisms of social change processes.

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based on a Newtonian worldview. "Chaos and complexity promise a postmodern revolution in science based on the notions of holism, interconnection, order out of chaos and self-governing, autonomous nature. *But where do the new ideas come from? Why they are the very same non-Western notions that modern science rejected in the 15th century as irrational.*" Sardar's basic contention is that the philosophical and metatheoretical underpinnings of the complexity sciences are based on Eastern philosophy, as opposed to Eurocentric science. He further contends (p. 677-678) that "despite its obvious challenge to...modern science, complexity is not a break from modern science *but an attempt at a quantum leap to a new level of multidimensional reduction and pluralistic control.*" From this perspective, the only really "new" thing about the 'new science' of complexity and chaos is the mathematics. Funtowicz and Ravetz (1994: 572) also note the "affinities with Oriental philosophy" of the complexity perspective.

This lack of fundamental and theoretical understanding has profound implications for practical and applied efforts toward implementation of change programs in organizations. That organizations can and do change is not at issue – at issue is whether the direction and consequences of change can be anticipated, understood, predicted and/or controlled. Such a concern is fundamental to management and managerial studies.

The major contention made to this point is that the emerging complexity sciences have the potential for extending and enhancing a theoretical understanding of organizational dynamics. In order to support this claim and develop an adequate *theoretical* approach to change and transformation, the complexity sciences must be integrated at the *metatheoretical* level of organizational analysis. In Part II the complexity sciences are considered more detail than the brief introduction offered in the present chapter. Chapter 4 discusses and characterizes the significant implications about system dynamics that derive from the Newtonian/Darwinian paradigm. Chapter 5 considers the complexity sciences in more depth, develops alternative implications and links these to the study of complex adaptive systems and a connectionist perspective on system behaviors. In short, Part II addresses the issues involved in integrating the complexity approach at the metatheoretical and paradigmatic levels of analysis. This provides the foundation for arguments presented in Part III and the background necessary for the development of an analytical model of the processes and mechanisms of organizational dynamics.

INTRODUCTION TO PART II

"We ought then to regard the present state of the Universe as the effect of its preceding state and as the cause of its succeeding state."
Pierre-Simon De Laplace

"Given for one instant an intelligence that could comprehend all the forces by which nature is animated...an intelligence sufficiently vast to submit these data to analysis...it would embrace in the same formula the movements of the greatest bodies in the universe and those of the lightest atom; for it, nothing would be uncertain and the future, as the past, would be present to its eyes."
Pierre-Simon De Laplace

"A very slight cause which escapes our notice determines a considerable effect which we cannot fail to see, and then we say that this effect is due to chance."
Henri Poincaré

"These 'far-from-equilibrium' conditions lead to a point of singularity that allows the inherent tendencies toward equilibrium to be overcome."
Leifer (1989: 906)

Part I delineated and delimited the general domain of the problem under consideration in this project: organizational dynamics, with a specific focus on organizational developmental and transformational processes. The arguments presented followed these general lines:

- An understanding of the mechanisms and processes of organizational change is central to management and the managerial disciplines. However, practical and applied efforts at implementing and controlling organizational change processes and programs have not been particularly successful.

- The need for an adequate understanding of organizational dynamics is becoming more important because of increasing rates of change and a need for more responsive and adaptive organizational forms.
- A primary reason for this limited success at the practical/applied is that there is an insufficient understanding, *at the theoretical level*, of dynamic developmental and transformational processes in organizations.
- The limitations of existing theory result, in part, from a lack of appreciation of *historical*, *contextual* and *processual* effects on organizational dynamics.
- An adequate theory of organizational dynamics must address (at a minimum) the *source*, *driver*, *director* and *modality* of change phenomena. An adequate theoretical treatment will provide insight into the potential for prediction and control of such processes.
- The complexity sciences offer a new perspective and novel insights into system dynamics and, thus, can enhance and extend knowledge of the processes and mechanisms of social system development and transformation. The primary need at this stage is for theoretical integration – and communication – of these insights.
- Because the implications and foundations of the complexity sciences differ radically from the implications and foundations of traditional organizational science, an analysis at the paradigmatic and metatheoretical level is a prerequisite to theory development. The theory

> must include an explanation of the linkages between micro- and micro-level elements and between the subjective and objective features of social phenomena.

The objective in Part II is to develop the implications and paradigmatic foundations of the complexity sciences in more detail and to compare and contrast them to the metatheoretical foundations of "traditional" and contemporary organizational science.

Chapter 4 examines traditional assumptions underlying theoretical perspectives on the behavior of complex systems. The "scientization" of social dynamics is discussed. Finally, the implications of the metatheoretical foundations of the dominant Newtonian/Darwinian paradigm are developed. Chapter 5 considers the approaches outlined in Chapter 3 in more detail. The implications of approaches to the study of complex system behaviors are extended to provide the basis for a description of complex adaptive systems (CAS) and a connectionist perspective on system dynamics. The implications of the complexity approach are contrasted to the "traditional" implications developed in Chapter 4. The discussion in Part II provides the foundation for arguments in Part III, where these implications are utilized in the development of an analytical model of organizational dynamics.

Although the complexity sciences are becoming more familiar to many organizational researchers and many available reference books on the subjects exist, a review of this material necessary for two reasons. First, much of the existing work on the complexity sciences in the social science literature considers only one, or at most two, of the approaches. The complexity sciences are broader and more inclusive than any one of the approaches, no matter how intriguing the merits of the specific approach. The aim is not, however, to construct a grand unified theory of complex systems. The much more limited goal is to provide an introduction and statement of implications suggested by the collection of perspectives falling under the general heading of the "complexity sciences." Thus, Chapter 5 juxtaposes the major approaches to complexity and discusses the assumptions, intentions, implications and purposes of each. Enough depth, and references, will be provided to allow interested researchers to pursue specific subjects in greater depth.

Second, since there is no generally accepted or agreed upon definition of the complexity sciences, it incumbent to explicitly state the meaning attached to the "complexity sciences." Given that, as Lewin (1994: 37) notes, "...complexity is a slippery term that means different things to different people," it is essential to define and explicate the perspective being developed. The central and major purpose of Part II is, thus, to make explicit statements of the implications from the complexity sciences that affect an understanding of dynamic processes in complex social systems and to compare those implications to those derived from Newtonian/Darwinian foundations.

CHAPTER 4

DESCRIBING AND EXPLAINING SYSTEMIC CHANGE

Morrison (1991) notes that the study of, and speculation about, the nature and underlying cause of change dates back at least to ancient Greece. The essential and opposing arguments on the nature and "reality" of change were outlined by Heraclitus and Parmenides and refined by Plato and Aristotle. The central issue concerns the ontological status of change: does change have a "real" existence external to human experience (are "things" constantly in a state of Becoming) or is "reality" essentially stable and change only an appearance (a state of Being)? While such philosophical speculation is not generally a part of organizational studies, it does provide some insight into the more fundamental problems involved in attempts to account for change phenomena. Additionally, it illustrates the point that such attempts are not new.

Indeed, Wagner (1995) notes the similarity between the concerns of ancient philosophy and many of the concerns in contemporary management literature (Table 4.1). Should, for example, organizational researchers and practitioners strive to describe and attain organizational rationality and stability in order to enhance efficiencies, predictability and control, or should the in order to enhance efficiencies, predictability and control, or should the existence and pervasiveness of change be accepted and embraced in order to avoid the stagnation and stasis of stability and inertia? Though the existence of change is acknowledged by most in the modern era, the nature of change and how to influence and respond to it are still central to the management of organization. The increasing salience of change phenomena – and an increased sensitivity of organizational researcher and practitioner to the problem – is evidenced by the recurrent criticism of a focus on outcome variables and the relative dearth of research on organizational processes and change-related dynamics. Though a focus on outcome variables and content specific research is likely to continue to dominate the field, there does seem to be an emerging trend toward a closer examination of processual and contextual variables (Bowditch and Buono, 1997). This chapter discusses change at a general level and examines the premises upon which traditional conceptualizations of change in system behaviors are based. The central argument is that, while traditional approaches to the explanation of systemic and organizational change may provide an adequate foundation for describing the processes of *morphostasis* (first order change), they are inadequate when attempting to explain the processes of *morphogenesis* (second order change). The first section of this chapter outlines a view of the historical development of "modern" scientific thinking and theorizing about change and its impact in the social sciences. The second section of the chapter presents a framework for the development of thinking about system behaviors, paying particular attention to the relationship between descriptions of "reality" and the underlying assumptions about that reality. As noted earlier, researchers must avoid the all too common fallacy of confusing reduced-form models with the reality they purport to represent. Even if this fallacy is avoided, it is still a "...necessary condition for <scientific> progress...that the relation between models and the real world be properly assessed" (Ruelle, 1994: 30). Failure to do so places the researcher in a position similar to that of Plato's prisoner, seeing only shadows of themselves and other objects (i.e., the models used to describe reality) on the walls of the cave and mistaking the shadows for reality.

The "Scientization" of Social Dynamics

The study of change in complex systems moved beyond the level of philosophical discourse of Greek metaphysics when Galileo developed the study of mechanics. However, it took the "...genius of Newton to create the first dynamical model by combining his laws of motion with his law of gravity. The whole idea of defining a model by expressing changes (or rates of change) of variables in terms of those variables started with Newton" (Morrison, 1991: 10). The significance of the Newtonian revolution is that, since Newton,

> ...the mission of the knowledge process has been to formulate hypotheses with which to predict outcomes, quantify and measure dynamics, falsify or validate theoretical predictions, replicate and re-replicate findings until zeroed in on a final, logically coherent theory which subsumed the behavior of all systems for all time. Given such theory, the future of a system could be predicted with great

> accuracy...This knowledge process consolidated into what we now call modern science (Young, 1991: 289).

Modern Science and Change

This view of the process of scientific knowledge generation and the attendant emphasis on the use of statistical tools and quantitative modeling techniques was soon adopted by the emerging social sciences.[1] At the turn of the twentieth century, statistical tools were increasingly integrated into, and emphasized by, social researchers. The incorporation of statistical tools into social research was seen to solve what Camic and Xie (1994: 776) refer to as the *newcomer's dilemma*. Any emerging scientific perspective must accomplish two tasks in order to be accepted as a legitimate field of study by the scientific community at large: establish some measure of *conformity* with existing perspectives and be able to *differentiate* itself from existing perspectives.[2] The incorporation of statistical techniques allowed the new social disciplines to

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[1]Young (1991: 299) refers to this process as the "false scientization of social dynamics." However, not all social scientists in the nineteenth century followed this trend. As Artigiani (1987: 249) notes, it "...became obvious that identifying intellectual progress with the metaphysics of modern science was at least partially counterproductive. Science was reducing all nature to a vast deterministic mechanism and describing that mechanism according to one-dimensional Newtonian physics. These circumstances caused humanist scholars to rebel. Their disciplines had to be independent of 'science' if they were to preserve a saving remnant of freedom, meaning, and humanity. The German philosopher, Wilhelm Dilthey, led the defense of humanistic studies, declaring them to have a subject matter, purpose, and methodology that was radically opposed to those of natural science." See also, Morrow (1994) on Dilthey and *hermeneutics*. This subject in considered in more detail in Chapter 6.

[2]For example, statistical modeling and quantitative methods allowed the sociologist to differentiate the field from related disciplines such as history, which has its own distinctive methodology. Thus, even if methods were not consistent across disciplines, proponents of a scientific approach could claim adherence to the basic tenets and canons of the scientific method.

demonstrate social science's conformity to acceptable models and practices as established in the "scientific" disciplines (i.e., the physical sciences) while, at the same time, allowing for a differentiation from the established fields by defining a domain not duplicated by other fields.

Camic and Xie (1994) argue that to many in the social sciences at the turn of the century (for example, Cattell in psychology, Boas in anthropology, Giddings in sociology, and Moore in economics), statistical modeling offered a resolution of the newcomer's dilemma through the belief that

> ...statistical tools were at once demonstrably scientific *and* capable of diversification; they thus allowed social scientists to display a general conformity with defensible scientific practices *and* to shape differentiated statistical approaches for their own disciplines (Camic and Xie, 1994: 776).

Political economists, especially, embraced this view of modern science and the knowledge production process in the late nineteenth century. Many of the preeminent economists in the late 1800s (such as Jevons, Walras, Edgeworth, Fisher and Pareto) all received their early training as physicists (Foster, 1993). These economists

> ...had entered the field of political economy from about 1870 on, to develop a formal representation of neoclassical economics. They all imported a particular physical metaphor into neoclassical economics: that of ***equilibrium*** in a field of force and its purpose was to give mathematical precision to the progressive, free-market ideas of Adam Smith (Foster, 1993: 977; emphasis added).

This equilibrium-based approach, founded on the understanding and underlying assumptions of the physical sciences at the time, offered a counter to the controversies and to the disturbing implications of the social dynamics of Marxian analysis. The equilibrium-based perspective is, however, inherently ahistorical. It gave "...ideological support to capitalism but no science of the unfolding of economic events" (Foster, 1993: 977). It was essentially a static, linear analysis of inherently dynamic, and potentially nonlinear, processes. Since the "changes, exceptions, contrarieties, variations and surprises" (i.e., discontinuities in expected system behavior) encountered in the social sciences did not conform to the linear euclidean geometry underlying the equilibrium perspective upon which the "modern" scientific method was based, these anomalies were treated "as error, poor theory, weak technique, observer bias or deviancy" (Young, 1991: 290). Erratic data that did not conform to, or fit, the accepted modeling procedures were seen as either stochastic "noise" or random experimental error.

With the wholesale incorporation of this view of the "proper" nature of science, along with the scientific method and its increasingly institutionalized view of the knowledge generation process, "prediction, quantification and validation became the pillars" of modern social sciences (Young, 1991: 290). Thus, the social sciences took the form, if not the substance, of the physical sciences. A reliance on linear quantitative methodologies, coupled with an equilibrium perspective, led to a social science and to a social research agenda that relied on static, cross-sectional and aprocessual methods. The dynamics of system change remained largely unexplored.

The incorporation of a natural science ontology, epistemology and methodology into the social sciences was not wholeheartedly, nor entirely, embraced by those in the "soft" sciences, especially those in steeped in the German tradition. The opposition between *Erklären* (explanation in the natural science sense) and *Verstehen* (understanding in the social science sense) served as a defense of the identity of the humanities against the dominance of the mathematization and formalization of the natural sciences (Bourdieu, 1992). This resistance to inroads by natural science provides the foundation for a basic dichotomy in modern social theory: the positivistic, realistic and nomothetic perspective on the one hand and the subjectivistic, ideographic, and nominalistic on the other. By any account, the positivist position clearly dominates the social sciences in general and the administrative and business disciplines in particular.

Empirical Analysis of Systemic Change

Until the late 1950s, empirical analysis of system dynamics was limited mainly to astronomers and physicists, though Loye and Eisler (1987: 59) note that 19th century social scientists such as Tönnies, Spencer, Marx, Weber, and Durkheim were grappling with "isomorphically the same questions of change as modern 'chaos' investigators in the natural sciences" in the attempt to understand the period of social upheaval attendant to the industrial revolution. Issues of sociological interest in the 19th century such as solidarity, conformity, charisma, and anomie could all be characterized as dynamic systems with latent chaos within apparent stability that conflicted with a view of society as a relative static or slowly evolving phenomena.[3] Empirical analysis of such dynamics was, however, beyond the tools available to researchers of the time and, as argued above, the quantitative techniques that were available led to an emphasis on static, content-centered research and theory. Analysis of social change, at this time, focused on qualitative methods, discursive argumentation and historical analysis (e.g., Weberian and Marxian analyses of capitalism and the industrial revolution in 19th century Europe; note also Durkheim and Tönnies on social change and evolution).

As statistical methods became more common in the social sciences, simple quantitative models were developed in an attempt to understand complex social behaviors. Though the phenomena of interest were acknowledged as complex, there was a widely held rationale for the construction of "oversimplified mathematical caricatures of reality" (May and Oster, 1976: 573): it was deemed possible to capture the essential characteristics and observed patterns and processes without being overwhelmed with detail. These attempts at the modeling of social behaviors generally followed procedures developed in the physical sciences. Before the development of sophisticated computational technology allowed for a closer

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[3]For example, Edmund Burke's organic theory of the state conceptualized society as a gradually evolving entity.

examination of complex system behaviors, the study of dynamic natural and physical systems was generally grounded in one of two approaches. Either the system was modeled (1) as a series of simplified deterministic equations, subject to analytic solution or perturbation techniques or (2) as a stochastic process, subject to the laws of probability and the Gaussian central limit theorem [or as some combination of the two approaches – the system modeled as consisting of both a "deterministic" and a random, or "stochastic," component; see Morrison, 1991].[4] Quantitative methods in the social sciences generally followed advances and models developed in the physical sciences and social researchers – at least those with a quantitative bent – accepted the conceptual distinction between probabilistic and deterministic descriptions of "reality."

Probabilism and Determinism

Probabilistic and deterministic descriptions of macroscopic phenomena in the physical sciences had coexisted for centuries (Ford, 1983). During the period 1650-1750, for example, Newton developed the calculus of determinism for dynamics while the Bernoullis simultaneously constructed a calculus of

[4]Chapter 8 presents several proposed typologies of modeling techniques and their relationship to one another.

probability for games of chance and various other many-body[5] problems. Ford (1983) notes that, in retrospect, it appears strange that no major confrontation ever arose between these seemingly contradictory worldviews. That such a confrontation did not arise is attributable to the success of Laplace in elevating Newtonian determinism to the level of dogma in the scientific faith. After Laplace, probabilistic descriptions of classical systems were regarded as no more than useful conveniences to be invoked when the deterministic equations of motion were difficult or impossible to solve. Moreover, these probabilistic descriptions were presumed derivable from an underlying deterministic structure (this line of argument is developed in Ford, 1983).

Despite the success of the Newtonian and Laplacian worldview, it did not go entirely unchallenged. The basis for the Newtonian approach to the modeling of dynamic systems is based on a differentiable equation describing the evolution of the system as a function of its initial conditions (i.e., the initial data collected on system behavior). As Thom (1969) notes, this general model

> ...applies to practically all known systems of any nature whatsoever, provided they are directed by a local determinism. The most outstanding example of this model has been given by Celestial Mechanics, with Newton's Gravitation Law defining the right side <of the equation>...The differential model...offers the ultimate motivation for the introduction of quantitative models in Science (Thom, 1969: 314).

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[5]See Morrison (1991) and Tabor (1989), among many others, for a discussion of the many-body problem in physics.

However, there are problems and difficulties associated with the practical application of this general model. Thom (1969) relates two of the most troublesome difficulties:[6]

> 1) Despite the widespread belief to the contrary, there are very few natural phenomena which allow a precise mathematical description, for which the right hand side of <the differential equation> is "exactly" known and given by explicit formulae. Gravitation and classical electromagnetism are practically the only cases that fulfill this requirement...
>
> 2) Even if the right hand side of the <equation> is explicitly given it is nevertheless impossible to integrate formally the system. To get the solution, one has to use approximating procedures (Thom, 1969: 314).

Because of these difficulties, mathematicians generally rely on perturbation techniques. That is, they attempt to determine experimentally what a slight perturbation (or change) in the variables on the right hand side of the equation has on the global behavior of the system (i.e., the left side of the equation). Such limitations of the approach did not go unnoticed in the 19th century.

Qualitative Dynamics

One of the earliest attempts to overcome the problems associated with the Newtonian approach to modeling complex dynamics was developed by Henri Poincaré in the early 1880s (Kaplan and Glass, 1995; Thom, 1969;

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[6]Readers interested in the mathematics of Thom's arguments are referred to his 1969 paper that provides the mathematical foundations of the theory of structural stability and provides the theoretical underpinnings of catastrophe theory. It serves our purposes here to descriptively relate his conceptual approach.

Gregory-Allen and Henderson, 1991). His approach, referred to as *qualitative dynamics*, was an attempt to solve the difficulties in finding exact solutions to complicated differential equations or the use of approximation and perturbation techniques for the solving of such models.

The method was, first, to develop a global approximation of a system; that is, a global geometric picture of the system of trajectories through phase space is developed. If this can be accomplished, rather than to look for exact solutions, the researcher can describe qualitatively the asymptotic behavior of any given solution.[7] As Thom (1969: 315) notes, "this is in fact what matters: in most practical situations, one is interested, not in a quantitative result, but in the qualitative outcomes of the evolution." For example, an engineer may be interested in determining whether the application of a given amount of stress will cause a bridge to collapse or remain stable (a qualitative result). In the social field, researchers may be interested in determining, not the quantitative affects of increasing social pressures on social structures, but at what point does social unrest result in revolutionary activity (a qualitative change in system characteristics). The focus was on the discontinuous "changes, exceptions, contrarieties, variations and surprises" that were not dealt with by traditional the reductionist and linear euclidean quantitative methods underlying Newtonian physics. Qualitative dynamics was an attempt to examine the system

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[7]Kaplan and Glass (1995) develop Poincaré's method in more detail on pages 253-259.

holistically, in order to understand its dynamical nature while focusing on qualitative outcomes, as opposed to efforts at quantifying incremental changes in system parameters.

The method proposed by Poincaré foreshadowed many of the concerns of the complexity sciences.[8] Even today, Poincaré's method "...is considered an advanced topic in mathematics; it is rarely presented in advanced courses at the undergraduate or even graduate level" (Kaplan and Glass, 1995). Moreover, in the late nineteenth and early twentieth centuries Poincaré's results were generally ignored by the scientific community at large, given the successes of the Newtonian approach to explanations of system dynamics. By the end of the nineteenth century, however, quantitative advances based on Newtonian physics in the physical sciences had ground almost to a complete halt. Morrison (1991) notes that, by the early twentieth century,

> ...classical mechanics ran out of problems that could be solved by calculus and approximation techniques. Modern physics shifted the focus of the scientific world to the scale of atoms (Planck's quantum theory) or the whole universe (Einstein's theory of relativity). Mathematics changed from a problem-solving activity into a study of axiomatic, formal systems (Morrison, 1991: 11).[9]

Scientists were beginning to conclude "...that nature was infinitely less docile than Newtonianism had imagined and that simplistic mechanical explanations

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[8]Kaplan and Glass (1995: 28) note that though "...the possibility for chaos in dynamical systems was already known to the French mathematician Henri Poincaré in the nineteenth century, the concept did not gain broad recognition amongst scientists until T.-Y. Li and J. Yorke introduced the term 'chaos' in 1975 in their analysis of the quadratic map."

were increasingly inadequate. In fact, by the 1920s it began to appear that science had reached its limits" (Artigiani, 1987: 250). Theoretical physics has come to describe the world in terms of two basic partial theories (the general theory of relativity and quantum mechanics) which are "known to be inconsistent with each other – they cannot both be correct" (Hawking, 1988: 12). This has led to a major effort in modern physics – the search for a Grand Unified Theory. Such a framework would provide a quantum theory of gravity relating macro- to micro-level phenomena and describe the forces that link elements at each level of the physical world.

By mid-twentieth century, the new multidisciplinary field of nonlinear dynamics, spawned by advances in computational technology, began a concerted effort to solve some of the puzzles presented by these apparent contradictions (Ford, 1983: 40). These contradictions concerned the relationship between deterministic and probabilistic views of nature, between continuous and discontinuous system behaviors, and between small- and large-scale phenomena. In doing so, many of the basic assumptions upon which the traditional views of change and the dynamics properties of system behaviors were based have been called into question. These issues can be understood within a framework that compares and contrasts differing views on system properties and dynamics.

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[9]However, Morrison (1991) views constructivist mathematics as a reaction to this formalist, axiomatic school of mathematics.

A General Framework for the Development of Systems Thinking

A general framework (Table 4.2) for understanding the historical development of the understanding of dynamic system behavior has been proposed by Ilya Prigogine and associates (1977, 1980, 1984) and extended to applications in the social sciences by Jantsch (1975, 1980). This work suggests an "historical three-stage framework for the development of science" (Loye and Eisler, 1987: 56). These three stages in the development of science and of scientific views on the processes of changes are: (1) deterministic change based on steady-state assumptions; (2) dynamic change based on equilibrium and homeostatic assumptions; and, (3) dissipative or transformational change based on system instabilities. Each of the stages view systems as a collection of interrelated and interacting elements. However, the assumptions underlying each stage lead to significantly differing implications.

Early Conceptualizations

Stage One. Concerns in the first stage centered on steady or equilibrium states as exemplified by the classical physics of Aristotle and early modern thermodynamics. Scientific advances in this stage were built on a closed system view of physical and natural phenomena and deterministic assumptions derived from the Newtonian worldview. The metaphysics of this stage see the world as fundamentally orderly, stable and predictable and led to the notion of a clockwork, mechanistic universe. Systems are driven by underlying deterministic laws and remain in equilibrium unless acted on by exogenous force (cf. Aristotelian/Galilean notions with regard to inertia). Since these underlying deterministic laws are knowable and there is an ultimate order to the universe, scientific progress depends on the discovery of the laws underlying this order. This knowledge can be exploited for prediction and control of the system of interest, resulting in the Laplacian notion of ultimate predictability.

These assumptions formed the basis of the Newtonian, reductionist approach to systems modeling (Allen, 1988). As discussed above, a set of deterministic differential or difference equations are developed which model system behaviors. Through correct specification (i.e., the correct identification of critical system components and the functional causal links between them), the behavior of the system can be understood, anticipated and predicted. Though there may be *practical* limits, there is no *theoretical* limit to predictability. Given correct specification of the model and accurate measurement of the essential variables, it is theoretically possible to determine all future states of the system.

Stage Two. In the second stage, the deterministic and mechanistic view gradually gave way to an organic model, though still based on an equilibrium perspective, with the advent of general systems theory (GST: e.g., Von Bertalanffy, 1975; Boulding, 1964; Katz and Kahn, 1966; Kast and Rosenzweig, 1972). This moved the study of system behavior from the realm of static, steady-state equilibrium of closed systems to the open systems notion of dynamic equilibrium (Ashmos and Huber, 1987). The open systems perspective emphasized the interaction of the system with its surroundings (i.e., environment). With this came the recognition of periodic fluctuations in system behaviors and a concern for the maintenance of a dynamic equilibrium, or homeostasis. Systems move in and out of an equilibrium condition – that is, the system never quite attains, but continually moves toward and remains near an equilibrium state.

Systems, in stage two thinking, are viewed as being more than just of the sum of its component parts and system behavior cannot (at least theoretically) be understood merely by examining those parts in isolation. There are synergies that suggest that the system is more than just the sum of its components (Kast and Rosenzweig, 1972). Therefore, emphasis is placed on the relations among system components in a holistic totality and the reductionism inherent in the Newtonian stage one view is de-emphasized. However, GST still emphasized order, regularity, and non-randomness in its approach and still relied on traditional linear and reductionist methodologies in empirical studies. Still dominant was the view that ultimately knowable and calculable laws govern systems. The emphasis on order and regularity suggests that technical rationality (prediction and control) can still be maintained through the process of learning the orderliness in the external world and adapting organizations to deal with it.

Assumptions of Stage One and Stage Two Thinking

The first two stages and their underlying assumptions form the basis of the orthodox conceptual framework on which much of modern science and have significant implications for views on the relationships and interactions of system elements. These assumptions and implications provide the foundation for much of current organizational theory. Four assumptions[10] are particularly noteworthy: equilibrium, feedback, hierarchical structuring and linearity (Table 4.3).

Equilibrium. The first fundamental assumption involves the closely related notions of *entropy, negentropy* and *equilibrium*, based on the second law of (linear) thermodynamics. The entropic process implies a tendency to maximal disorder and disorganization and is generally presented as a fundamental natural law. Because of the entropic process, closed systems (stage one) must eventually attain an equilibrium state of maximal entropy – total disorganization and death. Open systems (i.e., stage two systems that are open to their environment by virtue of permeable boundaries), however, can

[10]The assumptions noted here do not exhaust those that could be derived or discussed. They are, however, the most problematic when attempting to describe and understand how change occurs.

arrest the entropic process by the importation of more energy or resources from the environment than it expends in self-maintenance. The system, thus, attains and maintains a dynamic equilibrium. In either case, the system is driven by equilibrium seeking mechanisms.

> ***Assumption 1:*** *Systems "seek" to maintain a state of equilibrium.*
>
> ***Corollary 1.1:*** *Unless subject to abnormal pressures, such systems remain in equilibrium.*
>
> ***Corollary 1.2:*** *In a closed system, the result is a static equilibrium state of maximum entropy – a movement toward disorder, lack of resource transformation and, eventually, death and disintegration.*
>
> ***Corollary 1.3:*** *Open systems are able to maintain a state of dynamic equilibrium or homeostasis through the importation of negative entropy (a continuous inflow of materials, energy and information).*
>
> ***Corollary 1.4:*** *Forces and pressures for changes are, normally, generated externally. Internal forces and pressures that disrupt equilibrium are viewed as dysfunctional and abnormal.*

Only the acquisition of negative entropy (negentropy) and the storage of this excess energy can arrest the progression toward the final equilibrium point of maximal entropy and disorganization and allow the system to maintain or preserve its character.

However, the maintenance of a dynamic homeostasis through the importation of excess energy, which preserves the character through growth and expansion, does not explain how or why the system radically ***changes*** its character. Preservation implies some notion of the *status quo* or, at most, a gradual evolutionary process driven by an equilibrium maintaining mechanism (morphostasis); radical change suggests situations where the system undergoes dramatic, revolutionary change (morphogenesis). Stewart (1993) suggests that traditional scientific theory has been unable to provide an adequate explanation of the process that would reverse the second law of thermodynamics and that would provide an explanation of how systems undergo self-organizing and self-developing processes. The missing link between models describing system behaviors and such behaviors "is a kind of converse to the second law of thermodynamics, a valid mathematical law which asserts that under certain conditions self-organizing, self-complicating behavior must arise" (Stewart, 1993: 3).

Feedback. Second, the behavior of a Stage Two system (particularly in the maintenance of equilibrium) is largely the result of the operation of *negative feedback* that provides information to the system about its track through phase space. While equilibrium maintenance drives system behaviors (i.e., the need for change is driven by a state of disequilibrium), the direction is provided by negative feedback mechanisms (i.e., negative feedback loops indicate the direction in which such change must occur to restore a state of equilibrium).

> ***Assumption 2:*** *System behavior is typically directed by self-maintaining, negative feedback.*

Negative feedback occurs when an increase in a variable sets in motion a process (a "path" of effects through the system) that leads to a decrease in that same variable; or, conversely, a decrease in the initiating variable eventually leads to an increase in the variable. Negative feedback (also referred to as compensating, deviation correcting or self-limiting loops) enables the system to correct deviations from a chosen (or determined) course, to maintain its dynamic equilibrium, to preserve its current state and contributes to system stability. Thus, a basic tenet of the general systems perspective is the notion of self-regulation and the maintenance of the *status quo* (or equilibrium) as exemplified by the field of cybernetics (Wiener, 1948). When a system's (negative) feedback mechanisms fail, the system is unable to maintain its (dynamic) equilibrium and ultimately fails.

> ***Corollary 2.1:*** *Self-correcting negative feedback loops are the major mechanisms of equilibrium maintenance. Negative feedback provides information to the system about deviations from an equilibrium state. Thus, negative feedback serves to maintain the essential character of the system.*

Positive feedback, conversely, occurs when an increase (decrease) in the value attached to a variable leads to an increase (decrease) in the variable through the rippling of effects along the causal path leading back to the initiating variable. Though the existence of positive feedback is acknowledged, its significance is usually discussed in terms of "deviation amplifying loops" or "vicious circles" (see Axelrod, 1976; Hall, 1976; Masuch, 1985; Nelson and Mathews, 1991; Weick, 1979; Lundberg, 1980; Stacey, 1995). As Lundberg (1980: 253) notes, "...positive feedback has been cast in relatively negative terms, primarily because, unless it is fettered by paralleling negative feedback, systems would build up from some initial 'kick' towards self-destruction."

For example, Hall (1976) traces the path that the effects of a promotional program designed to increase sales at the *Saturday Evening Post.* The program designed to increase organizational performance, unfortunately, had the adverse and unintended consequence of contributing to its decline. The promotional effort (free trial subscriptions) was intended to boost sales volume by attracting new customers. However, as the proportion of subscribers on free trials rose, average subscription rates fell with the unintended consequence of reducing profits. To offset reduced profits, advertising rates were increased leading to reductions in advertising volumes, leading to further pressures on profits. The magazine was eventually driven out of business. This is a classic example of a positive feedback loop generating a "vicious circle" spiraling out of control and amplifying small changes in system parameters into large and undesirable effects. This preoccupation with the stabilizing influence and beneficial effects of negative feedback – and the supposedly dangerous and destabilizing impact of positive feedback – results from a focus on the maintenance of system stability and equilibrium.[11]

Corollary 2.2: *Positive feedback loops are deviation amplifying, destabilizing and disruptive to system behavior.*

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[11]However, Senge (1990: 81) notes that there is "nothing inherently bad about reinforcing loops" (his term for positive feedback). Positive feedback may result in "virtuous" as well as "vicious" circles of behavior. Maruyama (1963) and Forrester (1958, 1961), among others, also suggest the potentially beneficial aspects of positive feedback. However, the significance of positive feedback for system change and development has generally been overlooked because of the emphasis on "equilibrium biased theories of a mechanical or functional type" (Lundberg, 1980: 253).

As with assumptions regarding equilibrium, such assumptions are beneficial in explanation of morphostasis but contribute little to an understanding of morphogenic processes.

Hierarchical Structuring. Third, though second stage systems are acknowledged as being ordered hierarchically, it is implicit that system components are *nearly decomposable* into *discrete levels* (Stage One thinking viewed systems a completely decomposable).

> ***Assumption 3:*** *System elements are hierarchically arranged into subsystems that are, in turn, hierarchically arranged to form the total system. Elements and subsystems are discrete and (at least analytically) decomposable.*

As Simon (1962: 477) notes, this near decomposability "...is a major facilitating factor enabling us to understand, to describe, and even to see such systems, and their parts." This decomposability is analogous to the physicists' decomposition of the forces of nature and the grouping of force-carrying particles into four discrete classes (gravitational, electromagnetic, strong nuclear and weak nuclear) according to their strength and the particles with which they interact. However, as Hawking (1988: 49) notes, "it should be emphasized that this division into four classes is *man-made*; it is convenient for the construction of partial theories, but it may not correspond to anything deeper." The Stage Two, classic notion of hierarchy relies on the notion of discrete levels. Although this may be "conceptually and pedagogically helpful, the implicit discontinuities between even levels that appear singularly real and discrete are to some extent arbitrary. Discrete levels need to be recognized as convenience, not truth" (Allen and Starr, 1982: 6).

The assumption of near decomposability into discrete levels is a double-edged sword. To the extent that a system can be decomposed into its constituent parts, researchers are able to analyze complex behaviors which, if analyzed as a whole, would require such detailed knowledge of the system and a calculation of interactions so numerous and among so many elements as to be beyond manageability. However, the fact that these phenomena are (analytically) decomposable may lead researchers to ignore relevant factors (or to assume *ceteris paribus* conditions for all other variables) not only at the same level, but also more significantly, those above and below the focal system. To adopt such a methodology assumes that each discrete level in the hierarchy is merely an aggregation of elements from the previous level and is, at least implicitly, a reductionist stance. This problem of aggregation is one of the most enduring and vexing of all of social science (see, for example, Richards, 1996).

At a theoretical level, the nesting of systems and hierarchy of relationships has long been noted (Simon, 1962; Kast and Rosenzweig, 1972; Ashmos and Huber, 1987). However, as a practical matter, this hierarchical structuring is often ignored in the interests of convenience, manageability and ease of analysis. These assumptions and simplifications suggest two corollaries to the hierarchy assumption:

Corollary 3.1: *Boundaries between the constituent elements of a system and its subsystems are clear and distinguishable.*

Corollary 3.2: *Boundaries between the system of interest and its environment are clear and distinguishable.*

This focus on hierarchical structuring into discrete elements has contributed to the lack of development of multi-level (or cross-level) hypotheses and is one of the missed opportunities of the systems paradigm (Ashmos and Huber, 1987).

Linearity. Fourth, linkages between elements and components are conceptualized as linear. A cause induces some effect and the magnitude of that effect is directly and consistently proportional to the cause.

Assumption 4: *Linkages between system components (elements) and between the system and its environment are linear.*

Corollary 4.1: *There is a clear distinction between "cause" and "effect."*

Corollary 4.2: *Relationships between cause and effect are consistent and proportional.*

Traditional mathematical techniques based on Newtonian linear differential modeling, adopted by adherents in both stages, are the tools of preference. As Stewart (1993: 2) notes, "traditional scientific models use linear systems, which are easier to study mathematically, but nonlinear systems are more realistic." Much in the same manner that interactions among hierarchical levels are ignored in the interests of manageability, nonlinear methods are avoided because of their intractability. However, to reiterate an earlier quote, "there is no apparent reason, intuitive or otherwise, as to why human behavior should be more linear than other things, living and nonliving" (Brown, 1991: 1). This reliance on linear methods may be one of the reasons for the lack of a theoretical understanding of the nature of change and for the lack of significant results when attempting to model such change. The misapplication of modeling techniques may lead to this lack of significance and to the contradictory results often reported in the scientific literature. These "contradictory results...<may be> systemic and follow from attempts to apply linear methods to the nonlinear dynamic nature" of social and physical phenomena (Wolfson, Puri and Martelli, 1992).

Implications of Stage One and Stage Two Thinking

General Implications

These assumptions and their corollaries are incorporated in the social sciences almost wholesale from the natural and physical sciences. They suggest a set of implications for descriptions of system behaviors (Table 4.4).

> ***Implication 1:*** *Small changes in system parameters result in small, or incremental, changes in system behaviors. (Underlying principle: system stability from Assumptions 1, 2 and 4).*

Successful systems maintain their essential character through a gradual and incremental adaptation to changing environmental characteristics. Once the initial conditions are set, the system evolves along a deterministic phase trajectory driven by equilibrium maintaining and entropic processes and directed by self-correcting (negative and linear) feedback. Internally generated fluctuations and positive feedback is viewed as disruptive, abnormal or dysfunctional.

A deterministic worldview based on these assumptions leads to a conceptualization of natural and social phenomena as analogous to machinery (the mechanical model), consisting of direct (linear) cause and effect relationships between components and generating predictable outcomes.

> ***Implication 2:*** *A completely deterministic system results in behavior that is completely deterministic and ultimately predictable. (Underlying principle: proportionality and clear distinction between cause and effect from Assumption 4).*

An understanding of the interactions among the smallest components allows for prediction and control of larger systemic outcomes. This traditional scientific approach rests on a reductionist rationale of breaking systems down into smaller and smaller analyzable components – understand how the components work in isolation and one can build a picture of the complete system. Because relationships between components and elements of the system are linear, the elements and subsystems can be examined and understood in isolation. Aggregation of components is all that is necessary to achieve an understanding of overall system behaviors.

> ***Implication 3:*** *The best (only) method of understanding complex systems is to break them into smaller, more manageable parts. As the individual elements are understood, the elements can be reconstituted and combined to understand overall system behavior. (Underlying principle: reductionism from Assumption 3).*

Attendant to this view is the notion of a clockwork universe – the idea that the universe and all of its composite subsystems is an intricate but precise clockwork mechanism whose cogwheels move according to tidy mathematical 'laws of nature.' Change is essentially nonexistent except to the extent that the system is subject to entropic process – ultimately, system change occurs only in the direction of disorder and disintegration. Open system are able only to delay or deter such entropic processes through self-maintenance and the importation of negentropy. Such self-maintaining dynamics are gradual and morphostatic.

> ***Implication 4:*** *Unexpected system behaviors result only from complicated, hard-to-understand interactions among a system's internal components, or from an outside perturbation. (Underlying principle: determinism from Assumptions 2, 3 and 4).*

Because system elements are linearly linked and hierarchically arranged and system behavior is guided by self-maintaining feedback mechanisms, system dynamics are deterministic and amenable to reductionist analytic techniques. Future states (temporal system behaviors) are theoretically predictable, given sufficient knowledge about initial conditions and linkages between system elements.

Stage Two assumptions broaden this view of system behaviors to include a conceptualization of change as an incremental and adaptive process of establishing a "fit" between internal and external environments. In terms of social system behaviors, adaptive organizations adjust to changes in the environment (through negative feedback) as a way of maintaining an equilibrium between the environment and the organization. In addition, they are able to arrest the forces of entropy and inertial by a continual importation of energy, resources and information from the external environment. Adaptive organizations may be sidetracked from the attainment of organizational goals, but they adjust to changing circumstances (i.e., reestablish a dynamic equilibrium) to ensure organizational survival or, if unable to adjust quickly enough, they fall prey to the second law of thermodynamics and die.

Taken as a whole, these considerations suggest the last implication derived from Stage One and Two perspective:

> ***Implication 5:*** *System instabilities are inherently negative and dysfunctional. Efficient and effective system functioning requires that instabilities be dampened and/or controlled to minimize their negative effects.*

Implications for the Organizational Sciences

In the organizational sciences, Scientific Management is the clearest example of the mechanistic (Stage One) worldview. The practical result of this *weltanschauung* is a focus on rationalizing internal arrangements and to

> ...the assumption that it is possible to manage: to organize and control so that small units of work are clearly defined and organized, resulting in predictable products and services of the highest quality at the lowest cost, and of course leading to the highest profits. These hierarchical, command and control organizations reflect the Newtonian worldview (Euster, 1994: 63).

In practical terms, this view led to a production line mentality, where tasks are reduced to the smallest, most restrictive focus in the interest of efficiency.[12] The most efficient methods can be "discovered" through quantitative modeling and following established scientific canon. Though the Stage Two, open systems perspective broadened the scope of system behaviors to include interactions with the environment in which the focal system is embedded, the systems school is methodologically similar to Scientific Management in that quantitative analytic models and methods are extensively relied upon in the search for order among the interactions of complex variables.[13] As Shafritz and Ott (1987) suggest

> ...the systems school has close philosophical and methodological ties to the scientific management approach of Frederick Winslow Taylor. Whereas Taylor used quantitative scientific methods to find the "one best way," the systems school uses quantitative scientific methods to find "optimal" solutions. In this realm, the conceptual approaches and purposes between the schools are strikingly similar (Shafritz and Ott, 1987: 235).

A major reason for this similarity is that both stages emphasize the centrality of equilibrium. First stage thinking emphasizes the maintenance of an *internal* equilibrium through the operation of deterministic laws and change results from the law of entropy. The second stage perspective extends first

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[12]This view also underlies the planning mode of strategic management. This is discussed in Chapter 8.

[13]Scientific Management and General Systems Theory are used only as exemplars of Stage One and Stage Two thinking. Other perspectives could be cited but this was considered beyond the scope, given the purposes of the paper.

stage thinking by emphasizing deterministic interactions between the focal system and its environment. The focus is on maintaining an equilibrium position between *internal* and *external* factors: equilibrium between the focal system and its environment. In organizational terms, the implication is that as the external environment changes, management's role is to continuously find a balance, or "fit" (a dynamic equilibrium) between the orders of the internal and external environments. Balancing the internal and external, the basis of contingency theory, contradicts the deterministic view of *one* underlying order of Stage One thinking by positing one order for environmental conditions and one for internal system conditions (Leifer, 1989; for example, see Burns and Stalker, 1961; Lawrence and Lorsch, 1967).

From this perspective, organizations need to *differentiate* internal components in order to deal with external contingencies and to maintain an equilibrium state with its environment – in order to meet effectiveness criteria and ensure organizational success and survival. At the same time, the organization must *integrate* the internal elements in order to sustain internal equilibrium – in order to meet efficiency criteria, again to ensure success and survival. System success is determined by the extent that the system is able to synchronize the internal and external and maintain homeostasis directed by negative feedback mechanisms. System instabilities are seen to be examples of dysfunctional change and are to be avoided and/or diminished – system stability, reliability and predictability are the hallmarks of a successful system.

Conclusions

Two key points are made in this chapter. First is the suggestion that, historically, organizational and social researchers have adapted and adopted perspectives developed in the physical and natural sciences in efforts to explain organizational phenomena. Second, the argument is raised that assumptions and implications deriving from Stage One and Stage Two thinking dominate contemporary organizational theory. Note that an implicit assumption of most social science perspectives is that the "success" (defined either by survival or by some efficiency or effectiveness criteria) of a particular organizational form or structure depends on the maintenance of a dynamic equilibrium between the components or elements of the organization and between the organization and its environment. Both the strategic choice and ecological perspectives, in particular, are founded on similar equilibrium assumptions about system dynamics: system success, for both approaches, is based on "...a tendency toward equilibrium and thus stability, regularity and predictability" (Stacey, 1995: 477).

Ecological or allogenic approaches assume an equilibrium perspective by arguing that stability and equilibrium issues imply that organizations are relatively inert structures, at least as compared to rates of external and environmental change. Success depends on an equilibrium between the distribution of organizational forms and environmental characteristics and change results from births and deaths. Rational adaptation assumes that for the organization to operate efficiently and effectively, a dynamic equilibrium must be maintained between the organization and its environment. Misalignment with environmental contingencies inhibits effective and efficient performance. Similarly, views of organizational change processes as governed by random processes assume that organizations "seek" a dynamic equilibrium between internal structural arrangements and between the organization and its environment. In this case, the disruptions in system equilibrium are generated by randomly occurring events. When equilibrium is disrupted, the system is driven to regain a state of equilibrium.

However, the equilibrium perspective is inherently limited and does not provide a theoretically satisfying explanation of transformational and morphogenic change. Further, a focus on equilibrium criteria encourages organizational researchers to adopt an either/or position: either organizational change processes are internally driven and directed or those changes are externally determined. Chapter 5 describes developments in the physical and natural sciences that take issue with Stage One and Two assumptions. As has been indicated throughout the present chapter, each of these "traditional" assumptions has been criticized in a piecemeal fashion. The third stage in systems thinking – the complexity sciences – offers simultaneous criticism of all four assumptions, their corollaries and implications. More significantly, these attacks have been generated, for the most part, by researchers within the dominant paradigmatic framework. The fundamental question is why should organizational and social theory remain mired in "traditional" perspectives when the researchers in the physical and natural sciences are exploring new and novel explanations of system change and transformation.

CHAPTER 5

NONEQUILIBRIUM DYNAMICS AND COMPLEX ADAPTIVE SYSTEMS

The complexity sciences challenge Stage One descriptions of systemic processes as 'clockwork' mechanisms tending to a thermodynamic state of maximal disorder and entropy. The processes and mechanisms of such systems operate according to timeless functional laws that are discoverable using reductionist experimental methods. Similarly rejected are Stage Two explanations of system behavior as resulting from a dynamic equilibrium-based tendency to homeostatic balance between internal and external environments. These (Stage One and Two) assumptions and implications (Tables 4.3 and 4.4) provide the foundation for most of contemporary organizational theory and theoretical approaches to the explanation of the processes and mechanisms of organizational dynamics. The contention of the Stage Three approach, however, is that "...there are many examples, both in the natural and social worlds, which contradict both the static mechanical and the thermodynamic disordering notions of process" (Foster, 1993: 985). If the implications deriving from a particular set of fundamental assumptions appear not to be supported, this suggests a critical need to reexamine those assumptions. The Stage Three (i.e., the complexity sciences) approach offers such a reexamination.

Stage Three

The complexity sciences attempt to describe and explain the mechanisms of systems characterized by processes that result in increasing, not static (or homeostatic relative to its environment) or decreasing (i.e., entropic), degrees of organization. The essential question asked by complexity researchers is: *What accounts for the observation of real-world systems which appear to violate the entropic process and engage in self-organizing, autocatalytic behaviors?*[1] Theoretical perspectives based on Stage One or Stage Two assumptions, while offering the potential for explanations of morphostatic change through incremental adjustment to changing environmental conditions, are inherently unsuited to provide an explanation for account for this increasing organization. That is, such theoretical perspectives are unable to provide a convincing explanation of the mechanisms of morphogenic change processes.

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[1]Prigogine, Nicholis and Babloyantz (1972a: 38), in discussing the limitation of Darwinian selection processes to explain the emergence of prebiotic forms (i.e., how did these prebiotic organic compounds evolve into biological structures), frame the questions in this manner: "Is it possible to conceive of a type of selection pressure, compatible the interaction of <primitive> active polymers, that would direct the system to increasing complexity and organization? There is little chance that 'survival of the fittest' dogma, in the sense of maximum offspring, would help here."

The purpose in the present chapter is to examine how the fundamental assumptions and implications of the complexity sciences differ from those of Stages One and Two. This involves a more detailed examination of the five approaches to complexity introduced in Chapter 3. However, the focus *is not* so much on the five perspectives themselves (catastrophe theory, chaos theory, self-organized criticality, self-organization, and dissipative structures) as on how these approaches offer an alternative conceptual perspective to approaches grounded in traditional assumptions and implications. An examination of the differences in assumptions, and the resulting implications, are critical for the application of the complexity approach to the complicated behaviors of social systems. Stage Three assumptions are compared to those of Stages One and Two in Table 5.1 and the complexity science implications are listed in Table 5.2. These assumptions and implications are discussed in the present chapter.

Taken as a whole, various specific approaches to the complexity sciences are coalescing into a generalized approach to explanations of the behaviors of complex systems referred to as *complex adaptive systems* (CAS – see Figure 3.1). The next sections of this chapter describe the five selected approaches in some detail. The final sections of the chapter discuss how the assumptions and implications of the five approaches are being integrated into the CAS perspective. CAS are compared to cybernetic and open systems and linked to a connectionist model of system dynamics. The control parameters of connectionist models are described. These parameters are used as an organizing framework for the analytical model of organizational and social systems dynamics developed in Part III.

Explaining Sudden, Discontinuous Systems Behaviors

Conventional theoretical approaches, based on the assumptions of Stage One and Two thinking, suggest that small changes in system parameters result in small, or incremental, system behaviors (*Implication 1* – Table 4.4). If this is a true assessment of the reality of dynamic system processes, however, *what explains or accounts for sudden and discontinuous changes in system behaviors*? That these discontinuities occur in everyday existence seems a truism, yet theories based on Stage One or Two assumptions offer no satisfactory explanation as to why or how they occur.

Catastrophe Theory

Catastrophe theory is a mathematical approach to explaining systemic behaviors that attempts to map discontinuous dynamic behavior of a system subjected to continuous stimuli (Gregory-Allen and Henderson, 1991). Thus, catastrophe theory seeks quantitative explanations for qualitative – discontinuous or revolutionary – changes in system behavior[2] (Thom, 1975;

[2]However, as Kauffman and Oliva (1994) suggest, catastrophe models offer the potential for describing situations that exhibit *both* incremental and sudden discontinuous changes in behavior.

Zeeman, 1976; Gregory-Allen and Henderson, 1991; Oliva, 1991; Oliva *et al.*, 1992; Vendrik, 1993; Kauffman and Oliva, 1994).

Catastrophe theory takes issue with traditional research efforts that examine only gradual and evolutionary behaviors, particularly with regard to the modeling of those behaviors. System behavior has traditionally been modeled as a system of differential equations. However, as a descriptive language of system dynamics, differential equations have an inherent limitation: they can describe only those phenomena where change is smooth and continuous. Zeeman (1976) notes:

> In mathematical terms, the solutions to a differential equation must be functions that are differentiable. Relatively few phenomena are that orderly and well behaved; on the contrary, the world is full of sudden transformations and unpredictable divergences, which call for functions that are not differentiable (Zeeman, 1976: 65).

Catastrophe theory was developed as a mathematical method to be applied in situations where gradual and continuous forces or motivations lead to abrupt, discontinuous or divergent changes in system structures and behaviors.

Catastrophe theory is derived from topological analysis, a branch of mathematics that seeks to describe the properties of surfaces in many dimensions. This "...school of topological dynamists...has used topology, developed primarily for the study of continuous mappings in the most general sense, to deduce results about nonlinear systems" (Morrison, 1991: 11). Topology is involved because the underlying forces in nature can be described, at least theoretically, as smooth surfaces of equilibrium; it is where this equilibrium breaks down that catastrophes occur. The major task for catastrophe theory is to describe the shapes of all possible equilibrium surfaces. Once this has been accomplished, points at which equilibrium can breakdown (i.e., catastrophes) become mathematically locatable.

René Thom solved this problem in terms of a few archetypal forms, which he calls the elementary catastrophes.[3] As Zeeman (1976) notes,

> ...the power of Thom's theorem lies in its generality and its completeness. It states that if a process is determined by minimizing or maximizing some function, and if it is controlled by no more than four factors, then any singularity of the resulting behavior surface must be similar to one of the seven catastrophes (Zeeman, 1976: 80).

For processes controlled by no more than four factors, Thom has shown that there are just seven elementary catastrophes (Table 5.3; Thom, 1969; Zeeman, 1976; Gregory-Allen and Henderson, 1991; Guastello, 1995).

Modeling Catastrophic Behaviors

The cusp model[4] is the form most often used because of its relative simplicity and ability to capture complex behavior in a parsimonious fashion (Kauffman and Oliva, 1994). For example, Zeeman (1976) uses a cusp catastrophe model to examine canine aggression where behavior is determined by two conflicting drives: fear and rage, and their interaction.

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[3]The formal designation of Thom's work is the "*theorem on the singularities of gradient mapping*" – see Tabor (1989).

[4]The seven forms are the *fold cuspoid, cusp cuspoid, swallowtail cuspoid, butterfly cuspoid, hyperbolic umbilic, elliptic umbilic*, and *parabolic umbilic*. See Guastello (1995: 35-44) for a mathematical treatment of the seven elementary forms.

To apply catastrophe theory one must first identify variables or factors that are important in determining the behavior of the system of interest. For the 'cusp' model, all important variables must be collapsed into two independent variables (the control parameters) and one dependent variable (the response variable). One of the independents is a 'normal' variable, and the other is called a 'splitting' variable. The dependent variable is the 'answer,' which is frequently referred to as the behavioral or response surface (Gregory-Allen and Henderson, 1991).

Properties. Five properties must characterize a system or phenomenon in order to be described by the cusp model. These are illustrated in Figure 5.1.

1) **bimodality**: The dependent variable can exhibit sudden jumps from one mode to the other. The dependent variable can take on one of two possible values but cannot be both simultaneously. The current state of the system is determined by its previous location on the response (or behavior) surface – therefore it is state-determined.

2) **hysteresis**: The jump from the top sheet of the behavior surface to the bottom sheet does not take place at the same position as the jump from the bottom to the top. Once a transition is made from one part of the surface to another (in the folded area), a return by the independent variables to their initial values (at the point of catastrophe) will *not* result in a return of the dependent variable to its original value.

3) **inaccessibility**: There is an inaccessible region between the top and bottom sheets on the behavior surface (the middle sheet) indicating the area of least potential.

4) **divergence**: There is an implied possibility for divergent behavior (i.e., a small perturbation in the initial state of the system can result in a large difference in its final state).

5) **catastrophe**: Sudden, discontinuous changes along the dependent variable dimensions are possible (Zeeman, 1976: 70; Oliva, 1991: 609-610).

Strengths and Weaknesses of the Catastrophe Approach

The strength of catastrophe theory is that the seven elementary catastrophes can capture complex behavior by using significantly fewer nonlinear equations than the number of linear equations needed to describe the same phenomena (Oliva, *et al.*, 1992). Kauffman and Oliva (1994: 220) note, however, that "...catastrophe modeling and estimation...are in the pioneering stage; hence, like its distant relative, chaos theory, catastrophe theory does not make for safe research."

The most important problems in the development of the theory concern the understanding and classification of generalized catastrophes and the more subtle catastrophes that arise when symmetry conditions are imposed. In addition there are problems associated with how catastrophe theory can be employed with other mathematical methods and concepts, such as differential equations, feedback, noise, statistics, and diffusion (Zeeman, 1976). However, the early work has been generalized and catastrophe modeling is no longer bound by the polynomial representations developed by Thom (Brown, 1995).

The Catastrophe Controversy

Catastrophe theory was initially greeted with much fanfare and acclaim, with Thom's Structural Stability and Morphogenesis (1972) compared favorably to Newton's Principia. However, as Casti (1992b, 1994) notes, within five years critics of Thom's approach began to attack what they saw "...as the spurious, if not downright dangerous, applications claimed by the theory's proponents" (Casti, 1994: 80). These criticisms[5] resolve into four distinct lines of argument, involving: (1) the theory's mathematical and philosophical foundations; (2) the assumptions necessary to apply the theory; (3) the details of the particular application; and (4) the scientific attitudes and styles of the antagonists and protagonists. After the early fanfare surrounding catastrophe theory, its limitations appear to considerably outweigh some of the early, exaggerated claims made by its proponents. However, catastrophe theory is becoming more accepted as a modeling technique in appropriate situations. Moreover, its avowed agenda – which conflicts with implications based on traditional

[5]The reader is referred to Casti (1994) and Guastello (1995) for more on these criticisms of catastrophe theory. The principle critical review of catastrophe theory (which raised most of the issues) is Sussmann and Zahler (1978a, 1978b).

assumptions – of performing a mathematical examination of discontinuous behaviors resulting from small, incremental changes in system parameters and inputs represents a breakthrough in the development of the complexity sciences.

Implications

The significant point is that, by challenging the underlying assumptions of linearity, catastrophe theory challenges the assumption that small changes in system parameters and variable values result only in small, or incremental, changes in system behaviors. Catastrophe theory *quantitatively* demonstrates that even small changes in system (micro-level) parameters can result in sudden, discontinuous and *qualitative* changes in (macro-level) system behaviors. Further, these qualitative changes may result from internally generated mechanisms, not just from exogenous shocks to the system. Systems are not necessarily driven to a stability state of equilibrium and homeostasis but may be subject to periodic fluctuations and catastrophes. The quantitative approach to explanations of qualitative changes in system behaviors, as exemplified by catastrophe theory, provides the basis for the first implication of a Stage Three approach to system dynamics.

> ***Complexity Implication 1:*** *Small changes in system parameters **may** result in large, nonproportional or discontinuous changes in system behaviors.*

Predicting the Unpredictable

Implication 2 (from Stages One and Two – Table 4.4) suggests that completely deterministic systems exhibit behavior that is completely deterministic and predictable. However, there are many examples of systems that seem to defy all attempts at prediction and control. Traditional assumptions suggest that, if the proffered theory or model is unsatisfactory in the explanation of observed phenomena, the problem must lie with either an omission of significant explanatory variables, imprecise or incorrect measurement, or from the fact that the process under observation is not deterministic but stochastic or random. The fundamental assumption is that, except in the case of random or stochastic processes, ultimate predictability is (at least theoretically) possible. The question occurs: *Are there any limits, either theoretical or practical, to the predictability of system behaviors?*

Chaos Theory

Chaos theory, at its most elementary level, is an attempt to understand the seemingly random behavior exhibited by a simple deterministic system, consisting of only a few elements (or single variable), as it moves through phase space. Phase space refers to that geometric space whose coordinates are given by the set of variables defining the state of the system at any particular time. Chaotic systems[6] are those that appear to follow no apparent

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[6]See Brown (1995) for a formal mathematical definition of deterministic chaos.

pattern through this geometric space but are, in fact, completely deterministic and have an exact solution. That is, each value of the variables locating the system in phase space can be *predicted exactly* over time, given an *exact* knowledge of initial conditions and *precise* measurement changes in the variables. The focus in chaos research is on answering this seemingly paradoxical question: 'How can a deterministic system, governed by fixed rules that do not themselves involve any elements of chance, generate such random appearing behavior?' (Crutchfield, *et al.*, 1985; Butler, 1989: 36; Hansson, 1991: 55). The study of nonlinear dynamical systems suggests an answer to this question.

Though Poincaré[7] envisioned the potential for chaotic behavior as early as the late 1800s, the study of the chaotic behavior of dynamic systems owes its existence almost entirely to the computer. Before computational technology became powerful enough, working with nonlinear systems of equations was a practical impossibility (Morrison, 1991; Gleick, 1987: 63). The first investigator to find chaotic behavior through computer exploration of a simple nonlinear system was Edward Lorenz, a meteorologist at MIT. His research on the modeling of weather patterns begun in the early 1960s was, however, initially ignored by much of the scientific community (Morrison, 1991).

[7]Henri Poincaré, as suggested in Chapter 4, is an important and intriguing figure in that he anticipated many of these issues and concerns.

The first physicist to investigate nonlinear dynamics was Mitchell Feigenbaum in the mid-1970s (Morrison, 1991; Gleick, 1987). Feigenbaum discovered two noteworthy facts about some simple mathematical equations. First, if the results of the calculations were fed back into the original equations as inputs, results remained predictable only for a time. Beyond a certain point, results began to behave in what seemed a completely chaotic, or unpredictable, manner. Further work led to a second counterintuitive discovery: there were patterns underlying this apparent unpredictability, an apparent predictability in the form of recurring patterns of behavior. This recurrence of patterns is not limited to the temporal behavior of the system. Benoit Mandelbrot (1982) discovered spatial patterning in his work on fractal geometry.[8] The fractal nature of chaotic systems refers to the self-similarity at differing levels of examination. Thus, a fractal is a pattern that is repeated in a self-similar way at many different levels of a system.[9]

Characteristics of Chaotic Systems

As a result of these early investigations, the important characteristics of chaotic systems gradually emerged. First, dynamical systems consist of two

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[8] It is interesting to note that Mandelbrot, though originally trained as a mathematician, published much of his early work (c. 1962-1972) in economic journals but much of this work has been ignored (Mirowski, 1990; Morrison, 1991).

[9] Though central to chaos theory, a discussion of fractals and fractal geometry is beyond the scope of the concerns here. There are numerous references (and computer programs) to consult on the subject. See Mandelbrot (1977, 1982).

parts (Crutchfield *et al.*, 1985; see also Brown, 1995): (1) a *state* [the essential information about the system – the 'content' of the system]; and (2) a *dynamic* [rules that describe how the state evolves with time – the 'process' through which spatial elements interact over time]. Second, the interplay between the spatial characteristics, or state vector, and the iterative rules relating the state variables to one another (over time) can produce surprising behaviors. The features of chaotic systems are most often demonstrated by use of the logistic difference equation, also referred to as the population growth model (for example, see Kaplan and Glass, 1995; Cartwright, 1991; Butler, 1990; there are numerous references on this topic).[10]

The Logistic Difference Model

The logistic difference model, developed initially by ecologists to model growth characteristics of biological populations (Guckenheimer, Oster, and Ipaktchi, 1977; the model also provides the basis of the Lotka-Volterra equations used by Hannan and Freeman, 1989), has two main characteristics. First, change in the system (population growth) is assumed to occur in discrete steps, rather than continuously as in a differential equation. Second, the rate of change (growth) is fixed but limited by the capacity of the environment (in which the system is embedded) to support the population being modeled. That is, this

[10]However, Mirowski (1990: 301) suggests problems associated with a reliance on the logistic equation: "The issue of conceptualization of chaos in physics is much more complicated than these little mathematical exercises."

is a bounded system in that there is a limit to the "carrying capacity" of the environment – a limit to how large the population can grow. Mathematically, the basic logistic difference model is given as:

$$x_{t+1} = x_t * k * (1 - x_t), \qquad 0 < x < 1, 0 < k < 4$$

The behaviors of a system governed by the logistic difference model are graphically illustrated in Figure 5.2a (100 iterations) for all values of k and an initial population level of .5 (i.e., $x_t = .5$). Values of k from 0 to 4 are graphed on the horizontal axis; the size of the population (x_{t+1}) on the vertical axis. The BASIC program used to generate the illustrations is given in Table 5.4.

In this simple model, the system is defined by a state vector x_{t+1} at time t+1. This is sometimes referred to as a cross-sectional or synchronic profile. In addition, the system is characterized by the constant k that in terms of the population growth model represents the cyclical rate at which the population reproduces. Finally, the state vector of the system in any specific period t+1 is a <nonlinear> function of the system state vector x_t and the parameter k_t (i.e., the state of the system in the previous period). Note that population levels are stated as percentages, or ratios, of the maximum possible population size (0<x<1), given carrying capacity restraints of the environment in which it is located. The term ($1 - x_t$) is, thus, a limiting factor and allows for the modeling of constrained growth. At any specific time, it represents the "unused," or free, resources in the environment that could support further increases in the population under examination. Exclusion of the limiting factor models a scenario of unrestrained <linear> growth.[11]

Using the output of the system in one time period as input for the next, as above, is usually referred to as self-reference, iteration, recursiveness, or positive feedback. This should be compared to negative feedback loops that stabilize system behavior. However, if the loop is positive and nonlinear, an increase in the parameter k attached to the feedback loop can force the system into a chaotic state (Arthur, 1990; Hansson, 1991). The idea is that the movement of a system through phase space is dependent, not only on environmental (exogenous) factors, but also on the historical (endogenous) state of the system.

A dynamic, nonlinear feedback system may have motion through phase space that is *stable*, *oscillatory*, *divergent*, or *chaotic*, depending on the values of the constant, k.[12] For k less than 1, ($0 < k \leq 1$, $x = .5$) the parameter is insufficient to maintain positive growth in the long-term. Values of x, in this case, approach zero asymptotically, and eventually reach (at least for populations) the stable end state of **extinction** (Figure 5.2b). The higher the value of the growth parameter k and/or the larger the initial value of x, the flatter

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[11]X will have its greatest value when $x_t = .5$ and the maximum value will occur at k/4. Since population can never be less than zero nor greater that one (which is the maximum carrying capacity of the environment), k must fall between 0 and 4. This is also the equation for the parabola. Graphically, k represents the "height" of the parabola. See Baumol and Benhabib (1989), among others, for a formal description and development of the logistic equation.

[12]Cartwright refers to the phases as *extinction*, *stable equilibrium*, *dynamic equilibrium*, and *transition to chaos*.

the curve and the longer it takes for extinction to occur. For values of k between one and two ($1 < k \leq 2$), values of x reach a **stable equilibrium** (Figure 5.2b). The equilibrium level depends entirely on k and is given by

$$1 - 1/k$$

to a maximum of 0.5, where k = 2.

At parameter values between 2 and 3 ($2 < k \leq 3$), population again proceeds to a nonzero equilibrium, but the trajectory to that equilibrium is no longer a uniformly changing one. The equilibrium population is again given by (1-1/k) but, instead of approaching this equilibrium in a uniform manner as above, the trajectory is now asymptotic through ever-diminishing but regular oscillations – an oscillating state of **dynamic equilibrium** (Figure 5.2c). The size of the initial oscillation varies directly with the growth rate, while the rate at which the oscillations diminish varies inversely with the growth rate. Neither the equilibrium level nor (after the first few oscillation) the trajectory to that state of equilibrium is affected by the initial population.

As growth rate (k) goes above 3 ($3 < x \leq 4$), oscillations in the population level cease to be dampened and the oscillations become more dynamic. At rates close to 3, the population alternates periodically between two equilibria. As the growth rate increases, the two equilibrium points diverge, until (around 3.5) there seems to be four equilibria, rather than two. Soon these divide into eight, then sixteen, etc. (this type of behavior is referred to as **period-doubling** – Figure 5.2d). The patterns get successively harder to discern in this transition period and the behavior of the model becomes fully **chaotic** when $k \cong 3.570$ (Figure 5.2e), though zones of dynamic stability periodically occur. Furthermore, and only in this regime, the trajectory followed by the population is affected by the starting point (i.e., the size of the initial population). This transition from stable periodic cycles to chaotic behavior is called the **period-doubling route to chaos** (Kaplan and Glass, 1995). For a given growth rate in the chaotic region, relatively minor differences in initial population levels can result in dramatically different population trajectories.

In the sense meant in the preceding paragraph, "chaotic" means that the pattern of motion of the system through phase space (i.e., the successive population levels) is unrepeating and appears to be random. Despite its random appearance, however, it is completely deterministic and fixed in its past and future course by its dynamic properties (see Butler, 1990; Gordon, 1992).

System Attractors

The various equilibria that appear (before the onset of chaos) are often referred to as attractors. Stewart (1992) notes that:

> ...often points at great distances from one another all home in on particular regions of the phase space. These regions turn out to have structured geometric forms, and since they attract points, they're called attractors...it is important to remember that both traditional attractors and strange attractors are generated by simple processes (Stewart, 1992: 61).

Attractors, or "basins of attraction," refer to the pattern of activity that the system exhibits. Three fundamental types of attractors are recognized: fixed-point attractors, limit-cycle attractors, and "strange" attractors. *Fixed-point attractors* result in either extinction or stable equilibrium. An analysis of fixed-point attractors is the primary concern of equilibrium thermodynamics, where the end state of the system is predicated on the second law of thermodynamics (Coveney and Highfield, 1995: 152-154; Priesmeyer, 1992). *Limit-cycle attractors* lead to dynamic equilibrium, where the system cycles continually around the basin of attraction in a closed loop or cycle within the phase space. This type of behavior is referred to as a stable limit cycle (Kaplan and Glass, 1991: 241). *Strange attractors*[13] lead to complicated aperiodic behavior or to extremely long periodic orbits (Casti, 1994:29) and are in evidence at the transition to chaos.

Two distinct characteristics of the strange attractor produce the observed complicated behavior. First, unlike a limit-cycle, a strange attractor is extremely sensitive to initial conditions. The understanding that the long-term behavior of a system under the influence of a strange attractor depends on a complete specification of the initial conditions was a primary result of Lorenz's work. Second, unlike the limit-cycle, it has a *fractal* dimension (i.e., the geometric dimension of the system is a fraction). The fractal dimensionality gives rise to the statistical self-similarity that leads to a recurring geometry of shapes that

[13]Strange attractors were first described by David Ruelle, a Belgian mathematical physicist, in 1971. Since Ruelle's initial work, several forms of strange attractors have been identified, most notably the Lorenz attractor. See Casti (1994), among many others, for more on the Lorenz attractor, Mandelbrot sets, and strange attractors.

appear the same on all scales.[14] Strange attractors, thus, provide the underlying order observed by Feigenbaum and Mandelbrot. Deterministic chaos arises from the infinitely complex fractal structure of the strange attractor.

Implications

The logistic growth, or difference, equation is the simplest example of chaotic behavior in a completely deterministic system. More significant are implications arising from this very simple model for more complex, involved systems of equations. The requirements of *nonlinearity*, where responses by the system to changes are not simply proportional to the size of the change, and *feedback* (i.e., recursiveness or self-reference) account for one of the most commented on features of chaotic systems: the extreme *sensitivity to initial conditions* (the "butterfly" effect).[15] Sensitivity to initial conditions suggests that small variations in system behavior are amplified with ultimately huge consequences. Whereas in a linear relationship a given cause has one and only (proportional) effect, in nonlinear relationships a single action can have a host of different effects. The interactions soon become so complex that the

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[14] In Euclidean geometry, the term "dimension" refers to the number of values needed to specify the position of a point on an object or space. A point is zero-dimensional, a line is one-dimensional, a plane is two-dimensional, etc. Systems with strange attractors would have a dimension of 4.3, for example. See Kaplan and Glass (1991: 111-141) for a discussion of the mathematics of fractal dimensionality.

[15] However, see Morrison's (1991) comments on the "butterfly" fallacy.

links between 'causes' and 'effects' disappear. Kauffman (1991) notes, in this regard, that

> ...certain properties of complex systems are becoming clear. One phenomenon found in some cases has already caught the popular imagination: the randomizing force of deterministic 'chaos.' Because of chaos, dynamic, nonlinear systems that are orderly at first may become completely disorganized over time. Initial conditions that are very much alike may have markedly different outcomes (Kauffman, 1991: 78).

Because of this sensitivity, closely neighboring trajectories of nonlinear systems through phase space have been found to diverge *exponentially*, whereas regular (i.e., linear) trajectories are found to separate only *linearly* in time. This "...rate of divergence can be precisely quantified in terms of *Lyapunov exponents*, which measure the mean rate of exponential separation of neighboring trajectories" (Tabor, 1989: 148). For nonlinear systems governed by the same set of equations, and having very close initial conditions, the trajectories will diverge or separate over time. In the chaotic region, at least one positive Lyapunov exponent – indicating a positive rate of separation of the initial points in a given direction – is in operation (Hansson, 1991: 55; Casti, 1994: 99-100).[16]

Chaos theory, coupled with Heisenberg's uncertainty principle, provides a serious challenge to the Newtonian view that simple laws produce simple patterns and the Laplacian notion of a completely deterministic universe with

[16]Morrison (1991:146-150) provides additional discussion of Lyapunov functions and exponents as does Tabor (1989: 148-151). Kaplan and Glass (1995: 333-335) outline the procedures for calculating Lyapunov exponents.

the potential for ever-increasing predictability and control (Crutchfield *et al.*, 1986). That is, given sufficient data, the state of the universe could be accurately predicted and ultimately controlled.

At the quantum level, Heisenberg's uncertainty principle states that there is a fundamental limitation to the accuracy with which the position and velocity of a particle can be measured. Predictability is, thus, inherently impossible at the quantum level. Chaos theory, with its "...discovery that simple, nonrandom laws may lead to complicated, unpredictable behavior" (Stewart, 1993: 2), provides a source of uncertainty at the large scale. So much for the clockwork universe where, if one knows the laws governing a system, one can predict its temporal behavior. This twin attack, at both the small and large scale, calls into question the very theoretical foundations of determinism (Crutchfield *et al.*, 1986).[17] Ford (1983) sums up this line of argument:

> In this century, Einstein denied the Newtonian notion of an infinite speed, and Planck deprived us of our energy continuum. More recently, Heisenberg reminded us of limits on observational precision for conjugate variables. And, finally, algorithmic complexity theory asserts that no variable can be measured precisely. The number continuum is, physically speaking, a fiction (Ford, 1983: 47).

Beginning in the 1970s, many physicists pursued the idea that chaos theory could potentially account for the observed (and apparently chaotic) behaviors of

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[17]These are all the more significant because both chaos theory and the uncertainty principle represent attacks from *within* the dominant positivistic paradigm – they are not attacks from a subjectivist perspective. Gödel's Theorem (e.g., a geometry may be all-inclusive or it may be self-contained, but cannot be both at the same time) is also applicable to this point (see Hofstader, 1979).

complex systems. Although chaos theory provided many mathematical tools useful for the study of complexity,

> ...it did not capture the wide range of dynamics exhibited by complex systems. The explosive development of computer hardware and the development of new mathematical concepts helped raise the level of interest in complexity beyond the study of chaos (Ruthen, 1993: 132).

However, chaos theory was a significant step in the development of the complexity sciences. The central implication suggested by chaos theory is that even though

> ...we may fully understand the 'rules' that govern behavior at the individual or 'local' level, but the global result is nonetheless impossible to predict beyond anything but the immediate future...this problem is inherent rather than situational...what chaos theory suggests is that planning based on prediction is not merely impractical in some cases; it is logically impossible (Cartwright, 1991: 45).

From Stage One and Two assumptions, it is traditionally assumed that a completely deterministic system results in completely deterministic and (ultimately) predictable behaviors. Chaos theory questions the fundamental assumptions of linearity and self-maintenance through the operation of negative feedback that support equilibrium-seeking mechanisms. The implications following from chaos theory suggest that this implicit belief in ultimate predictability may not be the case for all systems.

> ***Complexity Implication 2:*** *A completely deterministic system can result in behavior that, while completely deterministic, is inherently unpredictable.*

Self-Organizing Behaviors and Hierarchical Structuring

Catastrophe and chaos theories focus on mathematical and quantitative descriptions of the temporal complexity exhibited by spatially simple (or reduced-form) systems. As such, the focus is on understanding how interactions between system elements and components generate discontinuous and chaotic behaviors. These explorations, though significant, provide only half of the picture of complex system behaviors. The "other side of the coin" presents this question: *How, in the face of so much potential for chaos and disorganization, do systems manage to exhibit so much stability and organization*? Self-organized criticality (SOC) is concerned with the question of how some spatially extended systems appear to spontaneously self-organize and how order arises out of this complexity over time. Traditional approaches assume that the best way to understand spatially complex systems is to break them into smaller, more manageable parts (*Implication 3* – Table 4.4). As the parts of the system are understood, the individual components can be reconstituted to understand overall system behaviors. Self-organized criticality suggests that this reductionist assumption may not be appropriate.

Self-Organized Criticality

The central questions addressed by the theory of self-organized criticality (Bak and Chen, 1991; Kadanoff, 1991; Bak, Tang, and Wiesenfeld, 1988; Carlson *et al.*, 1993; Ruthen, 1993) is fairly straightforward: Why is there so much complexity in the world? Why do some systems, both adaptive and nonadaptive, seem to evolve away from the extremes of complete order and complete randomness? Some researchers, most notably Bak, believe that SOC is one of the principles that guide systems on the path between complete order and complete randomness. His research suggests a class of systems that appear to evolve toward a critical state, a state balanced between order and disorder.

SOC attempts to describe the behavior of spatially extended dynamical systems – that is, systems with both temporal and spatial degrees of freedom. More than the other complexity approaches to the study of system behaviors, SOC attacks the usual strategy of studying such systems by reducing a given problem to one or a few important degrees of freedom (i.e., variables, factors, or components). The effect of interactions between the individual components, in a traditional research program, is usually dealt with in a perturbative (i.e., give the system a small bump and see what happens) manner and much insight into the behavior of dynamics has been gained by studying the behavior of such low-dimensional systems (after all, Newton wasn't "wrong"). The assumption, from the traditional view, is that the response of a large interactive system is proportional to the disturbance (or perturbation) and that the dynamics of large interactive systems can be described in terms of an equilibrium state that is disturbed now and then by an external force. Self-organized criticality is a reaction to the belief that the behavior of a large interactive system can be predicted by studying its elements separately and by analyzing its interactive mechanisms individually (Bak and Chen, 1991: 46).[18]

Some dynamical systems seem to act in a concerted way, where the individual degrees of freedom keep each other in a more or less stable balance, which cannot be described as a perturbation of some decoupled state, nor in terms of a few collective degrees of freedom (Bak, Tang, Wiesenfeld, 1988). The issue is one of interdependence, interaction and feedback. SOC purports to

> ...demonstrate numerically that dynamical systems with extended spatial degrees of freedom in two or three dimensions naturally evolve into self-organized critical states. By self-organized we mean that the system naturally evolves to the state without detailed specifications of the initial conditions (i.e., the critical state is an attractor of the dynamics) (Bak *et al.*, 1988: 365).

Weak Chaos and the Power Law

The differences between SOC and chaos theory are related in Table 5.5. In fully chaotic systems, a small initial uncertainty grows exponentially with time. Furthermore, as attempts are made to predict further and further into the future, the amount of information needed about the initial state of the system increases exponentially with time (i.e., the system exhibits sensitivity to initial conditions). For the most part, this exponential growth prevents long-term prediction. Through simulation studies SOC suggests that, for self-organized

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[18]Note also the claim that "...self-organized criticality is the only model or mathematical description that has led to a holistic theory for dynamic systems" (Bak and Chen, 1991: 46).

critical systems, uncertainty grows more slowly that it does for chaotic systems. The uncertainty increases according to a power law rather than an exponential law – that is, the distribution of events follows a simple power law. For example, if in a given time interval there is an event of magnitude 10,000 as measured in some arbitrary units, there will be approximately 10 events of size 1,000, 100 events of magnitude 100, 1,000 events of size 10, etc. (see Coveney and Highfield, 1995). This "cascade" of behavioral events allows for some level of predictability – even though any individual event may not be predictable (either as to time or magnitude), the distributions of events within the specified time horizon may be predicted. This behavior, called *weak chaos*, is a result of self-organized criticality (Bak and Chen, 1991).

Weak chaos differs significantly from fully chaotic behavior. A time scale beyond which it is impossible to make predictions characterizes fully chaotic systems. Weakly chaotic systems lack such a time scale and so allow long-term predictions, at least in a statistical and probabilistic sense. Bak and Chen (1991) suggests that because they find that all self-organized critical systems are weakly chaotic, it is expected that weak chaos is very common in nature. Discovery of the limits to such predictability is a central focus empirical analysis in SOC.

The Sandpile Model

The sandpile model is typically used to illustrate SOC (Bak and Chen, 1991; Carlson *et al.*, 1993). Grains of sand are dropped, one at a time, onto a pile of sand and the patterns of "avalanches" are observed. The sandpile has two seemingly incongruous features: the system is unstable in many different locations; nevertheless, the critical state is absolutely robust. On the one hand, specific features, such as the local configurations of sand, change all the time because of the avalanches. On the other hand, statistical properties (such as the size distribution of avalanches) remain essentially the same. An observer who studies a specific area of a pile can easily identify the mechanisms that cause sand to fall, and can even predict whether avalanches will occur in the near future. To a local observer (i.e., one on the sandpile), however, large avalanches would remain unpredictable because they are a consequence of the total history of the entire pile. No matter what the local dynamics are, the avalanches persist at a relative frequency that cannot be altered. This criticality is a global property of the sandpile (Bak and Chen, 1991; Ruthen, 1993).

As the grains of sand are dropped into the center of the pile, the system exhibits three types of behavior: **subcritical**, **critical**, or **supercritical**. The sandpile initially increases in complexity, growing out of the subcritical state (orderly phase) and collapsing when it reaches the supercritical state (random phase). As long as energy is added to the system (that is, grains of sand are dropped) the system remains in the critical state, and its dynamics never settle. No matter what done to the system – it can be perturbed it as much as one likes – it always returns to the critical state (Ruthen, 1993). The implication is that these systems evolve, or develop, to a state poised between the sub- and super-critical states – they "seek" the critical state (a balance between order and chaos). This is generally consistent with an equilibrium perspective, but the implications that follow from SOC are different.

SOC suggests that *composite systems* (the term is used to denote systems containing many components governed by many interactions) naturally evolve to a critical state. In this critical state, a minor event starts a chain reaction that can affect any number of elements in the system. A composite system is so complex that analysts cannot possibly construct mathematical models that are both realistic and empirically manageable. Thus, researchers exploring the phenomena resort to simplified, analytic models such as the sandpile.

Implications

Self-organized criticality implies the operation of a feedback mechanism that ensures a steady state in which the system is marginally stable against a disturbance. Additionally, the sandpile model implies three different hierarchical levels of organization on which natural laws might operate: an individual grain, an avalanche, and the composite effect of many slides. At the level of the individual grains of sand, a large avalanche is a very complex composite event, involving many displacements of grains. However, "...if one looks away from the individual grains and instead at the whole or, alternatively, at the results of many successive avalanches, one sees some understandable behavior. At each level, new 'laws of nature' emerge" (Kadanoff, 1991: 9).

A major implication of the theory of self-organized criticality is that large fluctuations in complex systems are intrinsic and unavoidable properties of the dynamics of the system. In self-organized critical systems periodic large-scale fluctuations are to be expected even in the absence of any common exogenous disturbances across sectors – the fluctuations are endogenous to the system (Bak and Chen, 1991: 53). Moreover, these fluctuations *cannot be analyzed through a traditional reductionist method of examining components in isolation*. New "laws" emerge at differing levels in the system. Thus, complex systems are not decomposable because of the complex nonlinear interactions between elements at different system levels. As a result of nonlinear interactions *across* levels, new behaviors emerge at any particular level that, even though dependent on levels above and below, are not deducible from or reducible to explanations at adjacent levels.

> ***Complexity Implication 3:*** *Complex composite systems cannot be understood through a reductionist strategy of examining individual elements or levels of phenomena in isolation, then recombining those partial explanations into a description of overall system behaviors. Such systems can only be understood holistically.*

Emergent Behaviors

The emergent properties introduced by SOC are an essential element in biologist Stuart Kauffman's approach to the understanding of complex and developmental system behavior. Traditional assumptions imply that unexpected system behaviors result only from complicated, hard-to-understand interactions among a system's components (*Implication 4* from Stages One and

Two – Table 4.4). Further, because of the hierarchical structuring and linear relationships between components, overall system behavior can be understood and predicted merely through the aggregation of the behavior of its individual components. However, this presents difficulties when attempting to explain morphogenesis – the appearance, or emergence, of new and novel system forms and behaviors. The question is *what explanation can be formed that can account for these emergent phenomena*?

The Self-Organizing Approach

In much of the current organizational science literature, the term "chaos" is often used to refer to the whole of the complexity sciences and study of nonlinear dynamic systems.[19] This is unfortunate in that chaos accounts for only part of the behavior of complex systems. Chaos and catastrophe theories are theoretical approaches to the study of spatially simple systems, governed by simple deterministic rules, which can produce complex, complicated temporal behaviors. The self-organizing approach is, in many senses, the complement, or mirror image, of chaos (Briggs and Peat, 1989; Kauffman, 1991, 1993; Leifer, 1989; Lewin, 1993, 1994; Stewart, 1993). Unlike chaos theory "...which is the generation of disorganized behavior from simplicity, complexity involves the development of an organized complex system from a random group with simple rules" (Stewart, 1993: 2). As such, the self-

[19]See, in particular, Loye and Eisler (1987) on this point.

organizing approach is closely related to the theory of self-organized criticality. In fact, Bak and Chen (1991: 53) note that "...the theory of complexity and the theory of self-organized criticality may generically be one and the same thing." SOC focuses on the explanation of how spatially complex systems that have the potential for chaotic behavior generate organized and patterned temporal behaviors. Kauffman's work on self-organizing systems focuses on developing an explanation and understanding of how new forms of organization and structure emerge from an initially disorganized collection of elements – what explains the emergence of structure (organized complexity) from chaos (disorganized complexity).

Forms of Complexity

Hansson (1991: 51) notes that there is "...a distinction between organized complexity and disorganized complexity. The latter is due only to a very large number of variables and is statistically predictable. Organized complexity has to do with *patterns that do not submit to the rules of statistics*." The self-organizing approach challenges the assumptions of traditional science that complements that of chaos theory. Chaos theory constitutes an attack on deterministic, Newtonian-based explanations of system behavior; the self-organizing approach takes issue with stochastic and probabilistic descriptions of such behavior. Organized complexity is due not to statistical properties and stochastic or random processes involving individual elements of the system but, rather, result from the complex interactions of many elements. Organized complexity is a result of the dynamic behavior of the system and is an emergent property of complex, nonlinear systems. An implicit consequence of this is that if organizational theorists wish to adopt the implications of the approach, the idea of statistical equilibrium must be abandoned. Complexity "adds up" and emergent order is a synergistic result; equilibrium tends to "spread out" via internal balances, thus averaging out any order.

In examinations of this emergent property, complexity theorists usually describe a system as a network of interacting elements but ignore nearly all detail. The regularities of a particular system cannot be explained in terms of the individual components (or individuals); the regularities are an emergent consequence of the *collective* and *interactive* behavior of all the elements. Complexity theory explores these interactions in effort to describe these emergent behaviors.

It becomes apparent, then, that a major difference between chaos theory and the self-organizing approach is in the questions that are at issue. On the one hand, chaos theory considers the problem of apparent system instability and disorder and illustrates how simple deterministic rules can produce disorganized behaviors (but possibly having a hidden, higher-level order). On the other, self-organization asks the question, 'If it is true that systems have such potential for chaotic behavior, what is the source of the order that *is* observed?' Complexity theory attempts to understand how spatially complicated and complex systems (i.e., having many elements) interact to produce complex but organized behaviors (Ruthen, 1993). Further, it attempts to explain how organized large, macro-level structures function when the micro-level elements that comprise the system are "swimming in a sea of chaos." The ultimate focus is on how ordered patterns arise in a fundamentally chaotic universe. That such simplicity may emerge from the complexity of fine detail at lower levels is a paradox that may occur at all levels of analysis.

Self-organizing systems are characterized as open systems exchanging energy, entropy (and negentropy) and material resources with other self-organizing systems. It is the interactive process, with time-dependent identity, that forms the focus of self-organization (Hansson, 1992). As a result, "...self-organizing is the capacity of open and living systems, such as we live in and we ourselves are, to generate their own new forms from inner guidelines rather than the imposition of form from outside" (Loye and Eisler, 1987: 56).

Reaction to Darwinian Evolutionary Processes

Biologist Stuart Kauffman (1991) has referred to this phenomenon as *antichaos*. His work suggests that

> ...some very disordered systems spontaneously 'crystallize' into a high degree of order. Antichaos plays an important part in biological development and evolution...Since Darwin, biologists have seen natural selection as virtually the sole source of that order <in biological systems>...But Darwin could not have suspected the existence of self-organization, a recently discovered, innate property of some complex systems...Selection has molded, but was not compelled to invent, the native coherence of ontogeny, or biological development...We may have to begun to understand evolution as the marriage of selection and self-organization (Kauffman, 1991: 78).

The important point is this: self-organization "...does not eliminate the hypothesis that selection created or enhanced the very ability to self-organize and also sorted among alternative modes of self-organization" (Reeve and Sherman, 1993: 23). Being "ordered" is not logically equivalent to being adaptive, so that self-organizing mechanisms for generating order are not *alternatives* to selective mechanisms; it is the *interaction* between selection and self-organization which is important (Reeve and Sherman, 1993). These efforts are in their infancy and

> Biologists have, as yet, no conceptual framework in which to study an evolutionary process that commingles both self-organization and selection...Neither alone suffices. Life and its evolution have always depended on the mutual embrace of spontaneous order and selection's crafting of that order (Kauffman, 1995: 8-9).

Kauffman's work attempts to simulate this "commingling" through an analysis of dynamic Boolean networks.

Emergent Computation and Boolean Networks

The self-organizing approach attempt to explain which systems tend to increase in complexity and organize themselves, why they do it, and where such behavior fits into the dynamical spectrum from total order to total chaos. The aim is to "...develop a coherent and comprehensive range of techniques for understanding the complex systems found in nature, and to codify their behavior in a simple set of basic principles" (Stewart, 1993: 3). A new branch of science called *emergent computation* aims to answer such questions (Stewart, 1992) using computer simulation to study dynamic systems.

A primary example of such simulations is Kauffman's work with the NK fitness landscape models of epistatic[20] interactions, where N = the number of elements in the system and K = the number of interactions among each N (Kauffman, 1993, 1995).[21] Kauffman has created simulated theoretical models of chemical "networks" where long molecules made of simple units react together under the control of catalysts, generating products that may themselves act as either raw materials and/or catalysts for further reactions. Experiments with such random Boolean network simulations suggest that what appear to be massively disordered systems can spontaneously achieve high degrees of internally generated order and coherence (Table 5.6). The simulations suggest that such networks

> ...can exhibit three broad regimes of behavior: ordered, complex, and chaotic. In the *ordered* regime, many elements in the system freeze in fixed states of activity. These frozen elements form a large connected cluster, or *frozen component*, which spans, or *percolates*, across the system and leaves behind isolated islands of unfrozen elements whose activities fluctuate in complex ways. In the *chaotic* region, there is no

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[20]Epistatic coupling (or epistasis) refers to the fitness contribution to the organism depends on its connections to genes at other locations on the chromosome. Simply put, this means that the contribution of any particular element of a system depends, not only on its own characteristics, but also on the inputs (K) from N other elements. Kauffman introduces this concept of "fitness contribution" of any particular combination of NK elements as a weight (a decimal between 0.0 and 1.0) to indicate how much fitness the combination contributes to the organism (Kauffman, 1995: 170-172).

[21]The reader interested in more detail on Kauffman's work is referred to The Origins of Order (Kauffman, 1993) which develops, in detail, his methods and results with simulated Boolean networks.

> frozen component. Instead, a connected cluster of unfrozen elements, free to fluctuate in activities, percolates across the system, leaving behind isolate frozen islands. In this chaotic regime, small changes in initial conditions unleash avalanches of changes which propagate to many other unfrozen elements. These avalanches demonstrate that, in the chaotic regime, the dynamics are very sensitive to initial conditions. The transition from the ordered regime to the chaotic regime constitutes a phase transition, which occurs as a variety of parameters are changed. The transition region, on the edge between order and chaos, is the *complex* regime. Here the frozen component is just percolating and the unfrozen component is just ceasing to percolate, hence breaking up into isolated islands. In this transition region, altering the activities of single unfrozen elements unleashes avalanches of change with a characteristic size distribution having many small and few large avalanches (Kauffman, 1993: 174).

These simulations suggest the hypothesis that networks poised at the edge of chaos can perform the most complicated, self-organizing tasks. A sufficiently complex mixture of such elements can replicate as a group, even if no single element can replicate by itself. The biological implication is that, if the initial "soup of chemicals" is complicated enough, the self-replicating chemistry necessary for life is bound to emerge. The system, as a whole, can exhibit autocatalytic properties even if the individual elements cannot. New forms and behaviors emerge spontaneously *as a result of the system of complex interactions*, not because of the functioning of any individual element in the system.

Networks poised on the edge of chaos (i.e., total disorder) appear to have an ability to perform the most complex tasks and appear to optimize both their evolvability and fitness. However, as provocative and suggestive

> ...as such computer experiments are, the science behind them lacks a solid mathematical theory of such phenomena, one explaining just why

> such things happen. We also need to understand the universal patterns common to all evolutionary systems, both organic and inorganic (Stewart, 1992: 62).

Thus, much of the exploration of self-organization is based on simulations of simple Boolean networks. They are not quantitative or mathematical approaches like catastrophe theory or chaos theory. Neither does it have the mathematical foundations of self-organized criticality. Nonetheless, several significant insights have been suggested by the self-organizing approach.

Economist Brian Arthur (1990, 1993) has used emergent computation to study the evolution of simulated economies. His results suggest the powerful effects of positive feedback loops in accounting for this evolution. Arthur notes that economies can be viewed as complex, evolving systems and that activities such as international trade, high-technology business and the emergence of new companies exhibit truly complex dynamics because they involve both *negative* and *positive* feedback mechanisms. Negative feedback maintains the balance between supply and demand. Negative feedback maintains the stability of the system, but provides no mechanisms for the emergence of new forces. Positive feedback, on the other hand, is destabilizing and disrupting. However, it does provide a mechanism for the development of new forces. If a firm gets ahead, it gains further advantage so that a clever strategy or luck can decide what company becomes a leader in a field. This mixture of positive and negative feedback presents two challenging problems for economists. First,

> ...it means that any given economic system can *evolve down many different paths*. Economists must therefore figure out how a system ends

> up on one particular path. Second, a firm that is choosing a product strategy must try to guess which strategies other firms might use, knowing that small changes in its own strategy might alter the direction of others. Thus, economists must decide how firms behave in such complicated environments (Ruthen, 1993: 134).

Foster (1993) attempts to integrate these self-organizing concepts into "evolutionary economics" in an effort to explain the order that is maintained in economic systems that have chaotic potential. He suggests that "...the self-organization approach, suitably adapted to the economic context, seems to offer scientific foundation for a post-Marshallian re-orientation of economics" (Foster, 1993: 990).

Implications

A primary implication of the self-organizing approach is that systems poised between the two extremes of a Newtonian clockwork universe and chaotic, random-appearing behaviors act in a way that is complicated, but which shows hints of patterned behavior.

> These systems seem to be at the transition between order and chaos. A central tenet of complexity theory is that selection or learning drives systems towards this edge of chaos. Systems that are too simple do not survive in a competitive environment because more sophisticated systems can outwit them by exploiting their regularities. But systems that are too random do not survive either. It pays in survival terms to be as complicated as possible, without becoming totally structureless (Stewart, 1993: 3).

Both order (self-organization) and disorder (chaos) are part of one grand picture – the relation between laws of nature and patterns of behavior (Stewart, 1993).

At heart is an attempt to understand the complex interaction between order and disorder.

Stage One and Two perspectives imply that unexpected and unexplained system behaviors result only from the complicated, hard-to-understand interactions among a system's internal components, or from an outside disruption or perturbation. The self-organizing approach suggests that, in some situations, unexpected and unexplained properties may spontaneously *emerge* from well-understood interactions among elements of a complex system. These emergent properties are not reducible to, nor can they be explained by, properties at the level of individual elements. Neither can these behaviors be explained solely in terms of forces (e.g., selection mechanisms) operating external to the system.

> ***Complexity Implication 4**: Unexpected system behaviors may be examples of emergent properties of systems whose elements and internal interactions are well-understood and completely specified.*

Dissipative Structures

Kauffman's work on the emergence of biological forms and structures through the interplay of external forces and internal forces is closely related to Prigogine's work with far-from-equilibrium chemical systems. Prigogine's original work in the 1940s led to his *theorem of minimal entropy production* and *dissipative structures*, for which he won the Nobel Prize in Chemistry in 1977. Dissipative structures focuses on systems in states of extreme instability (i.e., chaos) where morphogenesis, rather than only quasi- or marginal transformations and adaptation, occur. As such, the dissipative structures approach appears to contradict the assumption that system instabilities are dysfunctional (*Implication 5* of Stages One and Two – Table 4.4). Dissipative structures are systems that are "self-maintaining" and "self-organizing" (i.e., *autopoietic* and *autocatalytic*). Dissipative structures operate in a far from thermodynamic equilibrium (i.e., a state of instability) where behavior is determined by boundary conditions (i.e., they are environmentally dependent). Such systems are contrasted to systems in a state of thermodynamic equilibrium (which Prigogine refers to as a *dynamic* system – *cf.* Foster, 1993) where system behavior is determined by its initial state.

This notion of environmental dependence goes beyond the general systems view of the system as being *open* to its environment. In the dissipative structures framework, *interchange* is an essential factor underlying the system's viability (Baker, 1993) – the system and its environment are inextricably intertwined and inseparable. This implies that the system exhibits both a degree of self-determination and a degree of dependency, and that these facets are intrinsically related to each other. In the traditional open systems view, where the system and its environment are conceptualized as distinct entities (i.e., distinct and analytically separable levels in the hierarchical structuring of reality), the system *does* respond to environmental pressures and contingencies, but the *specific* adaptive response exhibited by any *specific* system is determined by its initial conditions. Once those initial conditions are set, the system evolves along a deterministic phase trajectory driven by equilibrium maintaining and entropic processes. This is not to suggest that non-equilibrium thermodynamic systems never exhibit an order and structure. Order in far-from-equilibrium systems does exist as a result of repetitive, patterned internal and external interactions that produce predictable results. However, this order and predictability is transitory. The pattern is repeated and repeated and then without warning, a phase change occurs.

There are four central characteristics or elements of the dissipative process:

(1) increasing disequilibrium leads to a bifurcation point or point of singularity where the system either

(2a) attempts to rely on existing mechanisms to dampen oscillations in a structure that is increasingly unable to cope, leading to eventual system decline and failure, or

(2b) engages in a process of symmetry breaking and transformation[22] by exploring new modalities of existence through

(3) a period of experimentation with alternate behaviors and structures which leads to a

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[22]In social systems, the symmetry breaking and exploration phase (2b) is similar (but not isomorphic) to Lewin's notion of "unfreezing." That is, organizational members come to the realization that "something needs to be done" to break the organization out of its inertia and that existing methods of operation are no longer suitable to the current situation. The process is similar to notions of "reframing," "establishing a new vision" and "changing the cognitive map." An inability to reach this stage (i.e., taking path 2a) underlies the Population Ecology view of structural inertia.

(4) resynthesis and reformulation around a new structure.

Figure 5.3 illustrates the dissipative process.

Over time, this new equilibrium becomes increasingly misaligned with its environment leading to another far-from-equilibrium state where the process is repeated resulting in a new structural arrangement. It is in this sense that the non-equilibrium approach implies "order through fluctuation" (Prigogine *et al.*, 1972a; Jantsch, 1975). However, it is not necessary that the new structural arrangements develop in the direction of more and more complexity. The important characteristic of the emergent structure is that the new arrangements are *able* to contend with increased complexity (Leifer, 1989), not that they are necessarily more complex in and of themselves. These characteristic elements of the dissipative process deserve a closer consideration in order to differentiate the non-equilibrium approach from approaches relying on equilibrium assumptions.

Disequilibrium

The first characteristic of dissipative systems is that – rather than essentially inert and immune to the influence of internal or external fluctuations or only adaptively responsive to environmental fluctuations – they periodically enter a far-from-equilibrium state characterized by inherent instabilities. Highly developed systems have elaborate mechanisms (negative feedback loops and buffering mechanisms, for example) to dampen the effects of internal and external fluctuations and to maintain equilibrium. The essential "goal" is to maintain efficiencies in acquiring environmental inputs and in the conversion of those inputs into usable forms of energy and the production of system outputs. Thus, for periods of time, essential system components may be buffered from large internal or external fluctuations or the fluctuations dampened such that they have a negligible impact on system behaviors and structures.

However, a system that continually "chooses" to use these buffering and dampening mechanisms to withstand change and restabilize equilibrium will, over time, become increasingly misaligned with its environment. At some point – because of inherent nonlinearities, positive feedback and hierarchical interactions between the system and its (external) environment and among (internal) subsystems – *either* small or large fluctuations in *either* the environment or in internal interactions can push the system beyond its capability to cope with the situation. This is in contrast to linear systems (both closed and open) where small forces produce uniformly small effects that can be adjusted to in an adaptive manner.

In a nonlinear dissipative system, however, when fluctuations push the system beyond it capacity to cope it faces a point of bifurcation (or point of singularity). At this point it will either dissolve into complete disorder (if attempting to rely on existing buffering and dampening mechanisms) or move to a state more able to deal with increased complexity that is far removed from its initial condition (e.g., Prigogine *et al.*, 1972a, 1972b; Gemmill and Smith, 1985;

Artigiani, 1987; Leifer, 1989; Baker, 1993). Prigogine *et al.* (1972a) argue for the necessity of a non-equilibrium perspective by contending that

> ...the apparent contradiction between biological order and the laws of physics – in particular the second law of thermodynamics – cannot be resolved as long as we try to understand living systems by the methods of the familiar equilibrium statistical mechanics and equally familiar thermodynamics (Prigogine, Nicholis and Babloyantz, 1972a: 23-24).

Thus, the dissipative structures model posits a transitional state occurring when *either* internal or external conditions of a system are turbulent enough to move it outside the parameters where it was able to maintain equilibrium. At this bifurcation point, the inherent tendencies toward equilibrium are overcome. Bifurcation points are mathematically locatable moments at which a destabilized structure can make a random, unpredictable and aleatory leap to one of several alternative stable states (Artigiani, 1987: 251).

If, for whatever reason, the system does not make this radical transformation and continues attempts to rely on existing coping mechanisms, it becomes increasingly misaligned with its environment. The greater the misalignment, the less it can depend on the environment for necessary resources. It becomes inert and subject to entropic processes and will die.[23] Thus, this transitional period of chaos and non-equilibrium is a *necessary*

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[23]This is the fundamental premise of the organizational ecology argument. Organizations are unable to overcome the stasis resulting from strong inertial forces because of the twin requirements of ***high reliability of performance*** and ***high levels of accountability*** (see Hannan and Freeman, 1984).

condition for an adequate explanation of morphogenesis and transformational change.

Symmetry Breaking and Transformation

The second characteristic or element is the process of symmetry breaking and transformation using new and radical modalities of structure and behavior to cope with new circumstances. This is the period of morphogenic change where existing functional relationships between components, patterns of interaction, rules, values, and belief systems that had been the source of equilibrium and stability for the system are disrupted. Beyond symmetry breaking, this period may suggest the need for a complete and total abandonment of the past. The system must, in some sense, "realize" that new coping mechanisms are necessary for continued existence, that past methods are no longer appropriate or beneficial to the system in its new circumstance.

Though the point of singularity is reached through historical processes that can be fully described (i.e., they are essentially deterministic), the transformation and leap to a new state is inherently non-deterministic and random. The resulting state is unpredictable, even given a complete understanding of initial and subsequent system conditions.[24] Thus the history,

[24]The notion that these transition points (i.e., bifurcations and catastrophes) are mathematically locatable is central to catastrophe theory (as discussed earlier). The role of randomness at the point of singularity in the dissipative structures approach is attacked on philosophical grounds by Thom. He argues that because movement at the bifurcation point (i.e., the resulting structure) results from deterministic – rather than random or stochastic – processes, system

the record of its experiences as a system in time, deterministically defines the system. However, the randomly generated leaps at the bifurcation point are inherently non-deterministic, again because of nonlinearities, self-reinforcing feedback and hierarchical structuring (Artigiani, 1987). For social systems, this process of symmetry braking and transformation is in some sense similar to Lewin's notion of "unfreezing" but it goes further to suggest, not only an openness to new possibilities, but a complete decoupling from past experiences.

Experimentation

The third element is the notion of experimentation and trial of new modalities of operating. After being decoupled from past modalities of operation, new methods and modalities must be explored. This is a period of variation and novelty generation and may signify a period of uncertainty and ambiguity for system elements. During this period of experimentation, variations (and what may first appear as errors) must be produced for a sufficient variety of new forms of organization to emerge. From these variations, the system "chooses" the most appropriate. Any particular form at this point may appear to be inappropriate for a given environment. The system may appear loosely coupled and free-form for a time. They are certainly not *efficient* systems during the periods of experimentation, transformation and

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states subsequent to the bifurcation or catastrophe can be predicted. See Artigiani (1987).

transition. Systems in the transitional, exploratory period may appear to lose coherence due to the increased amounts of energy, resources and skills that are expended on the internal workings of the system. This increased internal activity requires an "...accumulation of entropy which is dissipated by an open exchange with the environment thus allowing energy importation...to balance the production of increasing amounts of energy or resources" required for experimentation (Leifer, 1989: 906).

The increased need for resources[25] during this period can be illustrated by noting that the net use of resources by the system can be partitioned into two components. The first component of total resource usage is the resources used in the transaction process with the external environment. The second component is the resources used in maintaining the internal environment. As the use of resources is analogous to the use of energy, an increase in the use of resources means an increase in entropy, such that

$$d_tS = d_eS + d_iS \qquad d_iS \geq 0 \qquad (1)$$

where d_tS denotes the total change in entropy in the system, d_eS denotes the change of entropy in the input-conversion-output process (i.e., the flows of entropy due to exchanges with the external environment), and d_iS denotes the change of entropy due to necessary maintenance and support processes (maintenance of the internal environment). The d_iS term is always positive

[25]The following argument and illustration is adapted from Leifer (1989: 910-911) and Prigogine *et al.* (1972a: 24).

because some energy is always expended in maintaining the system's current state. For a closed system (i.e., having no interaction with its environment), the d_eS is zero and equation (1) reduces to

$$d_tS = d_iS \geq 0 \tag{2}$$

Thus in closed systems, entropy production is always positive and the system is subject to the second law of thermodynamics and tends toward increasing disorder and disorganization. In open systems, however, the d_eS in equation (1) may be either positive or negative. In order for the system to remain in a steady state at the same time total entropy increases, the change in negative entropy due to d_eS (interactions with the environment) must be at least equal to the increase in positive entropy generated by d_iS, such that

$$d_eS = -d_iS \leq 0 \tag{3}$$

Thus, there are two aspects of a system's functioning subject to entropy and efficiencies: (1) the input-conversion-output aspect (d_eS), and (2) the maintenance aspect (d_iS). Thus, the total amount of resources used and required by the system is a result of the resources used by two processes: (1) interactions with the environment (acquisition of resources) and resources used in converting those inputs into outputs, and (2) the activities used to maintain internal system *status quo* and stability. This is the significance of equation (1).

Internal maintenance is always a net drain on the system because they always cost resources just to "break even" and maintain the *status quo*. However, the interactions and conversion activities may be a net gain to the system if the benefits received from the resources are greater that the costs involved in converting them into a useable form (e.g., eating more than is necessary to convert the inputs into useable energy will result in obesity – the excess energy is stored for future use). Thus, for the system to be successful, the net gain (negative entropy) due to the input-conversion-output processes needs to be greater than the net loss (positive entropy) due to internal maintenance. This is the result suggested by equation (3). The discussion of negative entropy associated with the dissipative model, or d_eS, actually fuels *increased* entropic processes. It is the sudden increase in negative d_eS that makes possible the successful transformation of systemic processes.

Since the d_iS term has increased, due to complexity and experimentation, the importation of energy must be enhanced for the system to renew itself and to remain coherent – thus the term "dissipative structures." Dissipative structures maintain continuous entropy production and dissipate the accruing entropy through exchange with the environment. As Jantsch (1980) notes:

> It is not the statistical measure of the entropy share in the total energy of the system at a given moment that characterizes a dissipative structure, but the dynamic measure of the *rate of entropy production* and of the exchange with the environment, in other words, the *intensity* of energy penetration and conversion (Jantsch, 1980: 31).

In this manner, the system maintains its inner non-equilibrium and the non-equilibrium, in turn, maintains the exchange process. A dissipative structure, in this way, is constantly renewing itself, albeit inefficiently, to maintain a transformed and more effective way of operating.

Resynthesis and Reformulation

The fourth element of the dissipative model is the process of resynthesis and reformulation. The process of experimentation results in multiple possible new configurations. The preferred new configuration will be one that is optimizing with respect to making possible a high degree of energy throughput, and an openness to other systems in its environment. Once the transformed and restructured system of relations are internalized, deterministic processes reassert themselves. As entropy production decreases, the system becomes increasingly unstable as it attempts to cope with increasing environmental demands. Once transformed the system moves to a new, stable state where entropy production increases. This suggests that a dissipative system "learns" to be more efficient over time as it stabilizes the new characteristics of functioning. The preferred configuration of the new state will be one that maintains an openness with the environment while at the same time remaining loosely coupled to the new state, allowing for a greater openness to the next cycle of transformations. This reformulation/resynthesis stage is an *autocatalytic* process, where change builds upon change as fluctuations travel along positive feedback paths and interact nonlinearly among hierarchical levels in the system.

The dissipative structure perspective questions both the assumptions of determinism and order through equilibrium maintenance, as well as a conception of the system as distinct from the environment (Leifer, 1989). The differences between the equilibrium (GST) perspective and the dissipative model are that

> From the equilibrium paradigm perspective, rational organizations that become overwhelmed by variety in the environments attempt to cope by increasing their complexity, information-processing capabilities, and increasing their openness to environmental resources and skills. This provides the organization with increasing degrees of freedom but also runs the risk of system fragmentation and breakdown. The dissipative theory suggests that the presence of instabilities at the bifurcation point (where the limits of the organization's coping mechanisms are just exceeded) does not necessarily lead to chaotic random behavior, but instead offers the opportunity for a new dynamic order, which is able to handle increasing amounts of uncertainty and complexity. The key notion of the dissipative system model is that upon reaching the bifurcation point, the organization needs to operate qualitatively different than it did previously. That is, there is a transformation in both style and behavior, the form of which may not be able to be predicted before the transformation (Leifer, 1989: 904-905).

This suggests a possible reason for the seemingly contradictory claims for the complexity sciences. To the extent that organizational thinking is still dominated by the Newtonian determinist *weltanschauung*, the complexity sciences can rightly be characterized as a paradigm shift. To the extent that general systems theory and systems thinking dominates, the complexity sciences can be seen as an extension and refinement of the GST paradigm to include dynamic, nonlinear, or nonequilibrium aspects.

Implications

The dissipative structures approach suggests that Stage Three nonlinear feedback systems develop new forms of structure and behavior when they are pushed far from equilibrium. This insight implies fundamentally different assumptions about equilibrium, feedback, hierarchical structuring and linearity from those of Stage One and Two (Table 5.1). Nonlinearities, positive feedback, and the non-separable nature of the system, its sub-systems and the environment in which it exists (non-decomposability) all contribute to a view of system instabilities as inherent, inevitable and beneficial. There seems to be a fundamental relationship between states of bounded instability (or chaos) on one hand and the potential for morphogenic transformation on the other. Periodic instability *must* be experienced by the system for new modes of structuring to emerge from the point of bifurcation.[26]

> ***Complexity Implication 5:*** *Periodic instability is neither dysfunctional nor negative. Rather, such periodic fluctuations are necessary for the explanation of morphogenic processes and transformational changes in system behaviors and structures.*

Instability is, thus, not inherently negative or dysfunctional for systems, leading inevitably to a lessening of system efficiencies and effectiveness. Rather, systems periodically enter periods of instability leading to points of bifurcation

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[26]Of course, this does not imply that *all* system instabilities are beneficial. Such behaviors may be *necessary* for the explanation of morphogenesis, but they are not *sufficient*. This suggests the need for examining the circumstances and situations where instabilities are dysfunctional and where they have positive effects. Pursuit of such an examination requires a theory of the processes and mechanisms of change in social organizations.

where the system either degenerates or attains a new and enhanced level of functionality. These points of bifurcation are reached through historical processes that can be fully described because they are essentially deterministic. The history of the system, its experiences as a system in time, defines the dissipative structure. However, the randomly generated leaps at the point of bifurcation which generates its evolutionary structure are inherently non-deterministic and unpredictable (Artigiani, 1987).

The point to be emphasized is that the dominant perspectives in social and organizational theory are based on the "traditional" scientific worldview of the Newtonian paradigm. Systems, in the traditional view, are conceptualized as equilibrium-seeking entities guided by negative feedback mechanisms, consisting of a decomposable hierarchy of linear relationships between both internal system components and its external environment. The complexity sciences take issue with this conceptualization.

Integrating the Complexity Approaches

Each of the Stage Three approaches considered in this chapter constitutes but one perspective on the study of complex systems. Each approach frames the questions of interest differently and utilizes different methods and methodologies. Catastrophe and chaos theories rely primarily on quantitative and mathematical modeling techniques to explain sudden, revolutionary, discontinuous, and unexpected behavior (i.e., catastrophes and chaos). Self-organized criticality and self-organization utilize simulation techniques in efforts to explain how systems overcome the potential for chaos and catastrophe and exhibit apparent self-organizing, emergent, evolutionary, and developmental behaviors. The dissipative structures approach relies primarily on experimental techniques to examine the systemic processes of transformation and development. Further, each approach is rooted in a different scientific discipline – mathematics, physics, biology and chemistry. Thus, each is different in the questions of interest, the methods of choice and the discipline from which it arose.

However, all focus on the attempt to explain the complex temporal behaviors of dynamic systems. Further, all question the fundamental assumptions of "traditional" science and offer alternate assumptions about the importance and functions of (positive) feedback, (non)linearity, (dis)equilibrium, and (non)decomposability. Derived from these alternate assumptions are new insights and implications that offer the potential and promise for overcoming the limitations of the Newtonian/Darwinian paradigm. These insights and implications (integrated from elements of each of the five approaches) are coalescing into a connectionist view of complex adaptive systems.

Complex Adaptive Systems and Connectionist Models

The insights and implications derived from the Stage Three paradigm suggest a new appreciation of the role of complexity in an understanding of the processes and mechanisms of system change. These insights and implications provide the foundations for the integrative complex adaptive systems (CAS) approach. CAS – collections of a large number of agents or elements interacting with each other according to some schema (laws or rules of behavior) – learn and evolve through the interactions among constituent elements and through interactions with other complex adaptive systems. The features of complex adaptive systems can perhaps be best brought into relief by comparing the characteristics of CAS to those of two other well-known approaches to the explanation of system behaviors – cybernetic systems and open systems. The differences between the three approaches are summarized in Table 5.6 and discussed in the following sections.

Cybernetic, Open, and Complex Adaptive Systems[27]

Cybernetic Systems. Cybernetics (Wiener, 1948)[28] is essentially an application of engineering control processes to human activities. Cybernetics is based on the idea of feedback loops in which the "gap" between the desired and actual performance of an act is "fed back" to the system for use as a corrective measure for future acts. The system itself is generally viewed as a "black box" – only behavior (i.e., progress toward the goal or minimization of the performance gap) is of relevance. Cybernetic systems are goal-seeking

[27]This section is based Stacey (1996b).

[28]Wiener's original impetus for the development of the field of cybernetics was to improve the accuracy of British anti-aircraft defenses in World War II.

feedback systems that reactively adapt to their environment through the mechanisms of negative feedback. System goals drive activity but because the system is connected to the environment by feedback loops it is a subsystem (of the larger environment) that must adapt to environmental constraints. This adaptive morphostasis allows the systems to reach the desired end state (goals). Thus, though internally driven by goal-seeking mechanisms, change is externally directed – causal factors lie in environmental criteria. System change (and instabilities) results from the feedback loops that link the system to its environment. The existence of these feedback loops implies a circular causality, making relationships (in large systems) so complex that the internal causal structure difficult to understand. However, statistical links between external fluctuation and system response can be observed. Because of this, predictability of specific events and their timing is possible in a probabilistic sense.

Effective control of a cybernetic system requires anticipation of environmental (external) change and an internal arrangement of system components that contains as much variety as that exhibited by the environment. The major problem for control of a cybernetic system is not the uniqueness of external events, but their variety (or complexity) in terms of the number of discernibly different environmentai states presented to the system. The more variety and complexity of environmental states, the greater the number of responses required of the system. This concept is generally referred to as the *law of requisite variety* (Ashby, 1945, 1952).[29] Nonlinearity and positive feedback play no significant role in cybernetic theory – effective systems are self-regulating because of the mechanical features resulting from the structure of the control system. Successful cybernetic systems are those that maintain a state of stability and consistency (while making progress towards system goals, of course).

Cybernetic theory is founded on many, if not all, of the fundamental assumptions of a Stage One perspective. The primary measure of success is that the system maintains static or steady state equilibrium between components. Internal feedback mechanisms are largely ignored – only negative feedback from the environment is important in that this feedback allows the system to "judge" progress toward the system's desired end-state or goal. A well-designed control process makes the system self-maintaining so that internal mechanisms are not particularly important (the internal "black box").

Cybernetic theory implies a clear distinction between the external environment and the system, and between system components. They are not only analytically decomposable, they are empirically decomposable. Because

[29]The law of requisite variety finds expression in the organizational literature in Lawrence and Lorsch's (1967) conceptualization of "differentiation" – the more complex and uncertain the environment faced by an organization, the more differentiated it must be in order to operate effectively.

the linkages between the system and environment (and between system components) are linear, a relatively high degree of predictability results.

Open systems. General Systems Theory (Von Bertalanffy, 1968, 1975) extends the cybernetic view of systems in two ways. First, systems depend on the environment for more than feedback about progress toward goals – they are "open" to environmental influence by virtue of the need for the importation of the energy, information and resources required for system survival. These inputs are transformed or converted and the results are exported to the environment as inputs for other systems. Second, where the cybernetic approach viewed internal arrangement of system components as a "black box," GST stresses the importance of the internal composition of the system. Open systems are "systems" precisely because they consist of a number of component subsystems that are interrelated and interdependent.

An open system is, thus, a set of interconnected parts (elements, components, and subsystems) that interact with each other and with other systems in the environment in which the focal system is embedded. Interconnections with the external environment suggest that the system imports resources, information and energy across some definable boundary that separates the system from its external environment and other systems, and exports the resulting output across that same boundary. However, the boundary also serves as a linking mechanism between the system and its environment. Relationships across this boundary (boundary spanning functions) are constantly changing because environment contingencies are continually changing. Thus, the boundary serves a regulatory purpose: on the one hand it buffers and protects the system (and constituent subsystems) from fluctuations in the external environment while, on the other, it conveys information and drives changes in boundary spanning elements so that the system can adapt to environmental change. From this perspective, a primary organizational and system function is to manage the boundary conditions so that the system is insulated from external shocks while *simultaneously* remaining responsive to external contingencies.

Negative feedback is still crucial for the maintenance of a stable, though dynamic, equilibrium between internal components and between the system and its environment that is necessary for system survival. Positive feedback and nonlinearities (to the extent they are considered) lead to dysfunctional system behaviors and are counter-productive. Successful adaptation to environmental contingencies involves maintaining a stable equilibrium between forces for differentiation and those for integration (Lawrence and Lorsch, 1967). Open systems, like cybernetic systems, must maintain a sufficient degree of requisite variety in order to cope effectively with the external environment (i.e., they exhibit internal differentiation). Unlike cybernetic systems, however, open systems must achieve (beyond a sufficient degree of differentiation) a sufficient degree of internal integration so that the transformation or conversion process occurs as efficiently as possible. Open systems are not "black boxes" —

arrangement and proper alignment of internal elements and subsystems is critical for success. Likewise, a stable equilibrium must be maintained between internal control systems (which tend to inhibit change) and the boundary spanning mechanisms that allow for change, adaptation, and response to environmental pressures. As with cybernetic systems, though, success from the open systems perspective is judged by the ability of the system to maintain a state of stability and consistency, though the equilibrium requirements of an open system are more complex. For success, the system must jointly maintain a dynamic equilibrium between internal components (i.e., forces for integration) in addition to the maintenance of a dynamic equilibrium between the system and its environment (i.e., the forces for differentiation).

General Systems Theory is fundamentally premised on Stage Two assumptions. Rather than static or steady state equilibrium, open systems must maintain a dynamic equilibrium (or homeostasis) among internal subsystems and between the system and the environment. Emphasis is placed, both with regard to internal arrangements and to interrelations with environmental factors, on the beneficial aspects of negative feedback mechanisms for the maintenance of the dynamic equilibrium. Positive feedback is considered destabilizing. Though the system is embedded in an environment, and depends on that environment for inputs necessary for survival, the system, its subsystems, and environment are all conceptually and analytically distinct and (at least theoretically or nearly) decomposable.

Linkages among system components and between the system and environment are conceptualized as linear – nonlinearity is not considered an important element in the open systems approach.

Complex Adaptive Systems. From a cybernetic perspective, the environment is important as a source of information – through the operation of negative feedback loops – on progress toward attainment of system goals. An open systems perspective expands this view to suggest that systems are, in a very real sense, entirely dependent on interrelations with the environment. Implicit in both cases is that the environment is the critical factor in determining the success or failure of the system. Ecological and evolutionary perspectives represent the ultimate fruition of such a view. Internal arrangements are either disregarded (in cybernetics)[30] or viewed as elements that need to be structured or integrated most efficiently (open systems) in order to deal with environmental contingencies. Individual elements and components play a minimal role in system change and development.

In part large, this lack of regard for individual (i.e., micro-level) influence at the system level is a result of the hypothesized decomposability of elements, subsystems, systems and environments. Linkages between micro-level elements and macro-level system developmental and transformational processes are not considered theoretically significant. It is not that individual

[30]Except, of course, to the extent that internal elements must be differentiated enough to maintain a sufficient level of requisite variety.

level phenomena are unimportant; indeed, much effort in the social sciences is geared to an analysis and explanation of individual behaviors. It is that individual factors can be decoupled from system level phenomena, and vice versa. The complexity sciences (and the implications derived above) suggest that this decoupling represents a major limitation of traditional explanations and theoretical approaches. Micro-level interactions are not only significant; they are crucial in explanations of the behavior of complex systems.[31]

The internal nonlinearities and feedback loops that are fundamental properties of CAS generate structured patterns of behavior that emerge through a complex web of interactions among individual elements of the system. System elements are connected by these webs of interaction, not only to other elements of the system, but also to other systems in the environment. These behavioral patterns can emerge unintended and unplanned (perhaps contrary to intention and plan) leading to complicated and hard to isolate chains of cause and effect. In many cases, the cause-and-effect structure becomes completely hidden. This web of linear and nonlinear (both positive and negative) loops results in an emergent structure independent of environment constraints and

[31]The assumptions and implications of Stage One and Two perspectives led, in large part, to a basic dichotomy in the social sciences – the division of the organizational sciences into macro- and micro-level domains. Macro-level theorists generally concerned themselves with systems-level and environmental interactions (e.g., strategies, formal structures, technologies, etc.). Micro-level theories focus on individual and group level phenomena (e.g., motivation, leadership, group behaviors, etc). Thus Warren Bennis' famous characterization of the state of the discipline as either concerning "organizations without people" or "people without organizations" (Bennis, 1959). These issues are revisited in Chapter 7 where the implications of the complexity sciences and complex adaptive systems are applied to developmental and transformational change in social organizations.

contingencies and can result in unexpected and counter-intuitive outcomes. These characteristics make prediction of specific sequences of events difficult, if not impossible. Quantitative analyses become less important – the discovery of qualitative patterns becomes more significant. To the extent that these qualitative structural patterns can be understood, points of leverage (pressure points) can be identified where efforts to change system behaviors may have the most effect. However, attempts to manipulate these pressure points may lead only to compensating and offsetting behaviors.

Implications

Following from the implications developed previously, complex adaptive systems can operate in several distinct modes: states of stable equilibrium, unstable equilibrium, in far-from-equilibrium states, or in bounded instability at the "edge of chaos." Thus, CAS are paradoxical systems. One the one hand, they are pulled toward stability by the needs for integration, maintenance controls, and for adaptation to the environment. On the other, they are pulled toward disintegration and instability by the activities of individual elements, the need for differentiation, division, decentralization, and isolation from the environment. If the system succumbs to the forces for stability (becomes frozen in stability), it becomes inert and unable to respond to change. If the system succumbs to the forces of instability, it disintegrates. Thus, the hypothesis that successful systems are poised on the edge of chaos, on the borders between stability and instability.

CAS are subject to periodic fluctuations and bifurcations in internal arrangements that are generated by the temporal interactions of positive and negative nonlinear feedback loops. Positive feedback is particularly significant in learning and adaptive behaviors, in system development and transformation. Not only are internal elements so connected, the system is linked to elements and systems in its environment by such connections. Because of this complicated web of interactions among system elements, and between the system and its environment, the totality cannot be decomposed. System components are non-separable; systems and their environments are non-separable.

The primary point to note is that system development and transformation depends not only on characteristics of the external environment. Internal factors play a major role. It is through the interactions of all elements, internal and external, that structure emerges. The importance of such interactions suggests that the processes of developmental and transformational change result from the interaction of both processes at the environmental level and the self-organizing processes at the individual level (White *et al.*, 1997). System behaviors are driven by control parameters that "push" the system into the frozen/static, complex or chaotic regions and provide the linkage to the external environment. System behaviors are directed by control mechanisms that govern interactions among individual elements of such systems. Such macro-level processes (parameters that link the system to the environment) and micro-level interactions (mechanisms that link system elements) intersect at the system level. Behaviors and structures in complex adaptive systems result from the interaction of control parameters and control mechanisms.[32]

As a final note, it is stressed that each subsequent perspective (*cybernetic* to *open* to *complex*) does not eliminate, or negate, implications from the preceding view. Stage One assumptions are not replaced by those of Stage Two – they are enhanced. Similarly, Stage Three enhances and extends the insights of Stages One and Two. Some systems may exhibit a (Stage One) static, steady state equilibrium during some periods, a dynamic equilibrium at others, in addition to periodic fluctuations and bifurcations. Stage Three CAS consist not only of nonlinear positive feedback loops – they are a mixture of such connections in addition to linear, negative loops. CAS are complex systems, not only because of the web of nonlinear interactions, but also because they include all the characteristics of cybernetic and open systems. A complex adaptive system incorporates all of the Stage Three insights – linearity and nonlinearity, hierarchy and nondecomposability, equilibrium and nonequilibrium, and positive and negative feedback (Table 5.7).

Connectionist Models

An identification of the processes and mechanisms explaining emergent behavior is central to the study of complex adaptive systems. In the complexity

[32]Control mechanisms and control parameters will be further specified in the discussion of connectionist models.

sciences, particular attention has been given to the notion of *connectionism* where a population of interacting units is represented as a network of nodes (i.e., elements) linked by connections (Waldrop, 1992). Connectionist models have had an impact on many areas of scientific inquiry. Most notably is the field of artificial intelligence and neural networks[33] where researchers use webs of artificial neurons to model perception, learning processes and memory (Waldrop, 1992; Coveney and Highfield, 1995). Indeed, node-and-connection models underlie so much of the work in the complexity sciences that may they provide a common framework for research into complex systems (Waldrop, 1992).

In the basic connectionist model, the behavior of the system (or network) as a whole is determined almost entirely by the connections since the nodes are so simple.[34] For example, the difference between the *genotype* (the genetic blueprint encoded in an organism's DNA that determines cell interactions) and the *phenotype* (the structure resulting from those instructions) suggests that these concepts are applicable to the computational study of artificial life and

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[33]Neural network models challenge the "symbol-processing methods of mainstream artificial intelligence" research (Waldrop, 1992: 289). The neural network approach utilizes parallel processing as opposed to sequential processing common to most computer programming (see Coveney and Highfield, 1995). This area is closely related the field of computational neuroscience.

[34]The basic connectionist methodology is similar to the methods of sociometry, the study of sociograms, and social network analysis. See, for example, Kerlinger (1973), Harary, Norman, and Cartwright (1965), Wasserman and Galaskiewicz (1994). These sociological efforts, however, tend toward cross-sectional, synchronic analyses. There are numerous other references in the sociological literature on these subjects. Connectionist models are more directly concerned with the dynamic behaviors of collections of interacting elements.

intelligence. The terms used in connectionist approaches are GTYPE or *generalized genotype* (any collection of low-level rules that link individual elements) and PTYPE or *generalized phenotype* (the structure and/or behavior that results when those rules are activated). In a conventional computer program, for instance, the GTYPE is the computer code and the PTYPE is the resulting response of the computer to user input. These two factors (basic rules and resulting behavior/structure) form the central concepts in the connectionist perspective (Waldrop, 1992).

It is generally impossible to predict PTYPE behavior from a given set of GTYPE rules. Moreover, given the specification (or desire) for a certain PTYPE behavior or structure, there is no general procedure for finding a set of GTYPE rules that will produce it. In computer science, programmers use well-tested algorithms to solve precisely defined and specified problems within a clearly defined environment. However, in the poorly defined, constantly changing environments faced by living (both biological and social) systems there seems to be only one way to proceed: generate sufficient variation through experimentation with alternate methods of structuring interactions among the elements of the system.

Exploitation and Exploration. In theory, in order to modify a system's PTYPE behavior or structure one need only to modify the GTYPE of the system – the characteristics of the connections between nodes. There are two ways to accomplish this modification. First, the "strength" of the connections can be modified while leaving the existing connections intact. This has been referred to as *exploitation learning*: improving what is already in place through a quantitative change. This is usually accomplished by negative feedback loops where the network (or system) responses to a series of inputs are used to "tweak" the connections up or down in strength until the "right" response is obtained. As such, exploitative learning implies equilibrium maintenance, gradual and developmental change, and morphostatic processes.

The second method of modifying system behavior is to change the configuration of connections. Such fundamental restructuring of elementary interactions may entail removing or adding connections and result in different level of connectivity (i.e., density of connections) in the system. This is a more radical method of modification as has been referred to as *exploration learning*: doing things in a qualitatively different manner. Implicit in exploration learning is the process of symmetry breaking and experimentation. Exploration learning involves morphogenesis and transformational change.[35]

Control Parameters and Control Mechanisms. It is significant to note that the framework provided above refers to *internal* connectionist models (Holland, 1995). The GTYPE is internal to the system of interest and may be directly applicable only to "lower" level systems. The system receives inputs

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[35]The differences between exploitation and exploration appear consistent with the notions of system efficiency (i.e., "doing things right") and system effectiveness (i.e., "doing the right thing").

and then converts those inputs into outputs and/or changes in its internal structure or behavior based solely on the internal GTYPE. A stimulus leads to a response that alters either the strength between existing connections (exploitation) or the number and arrangement of connections (exploration).

In a complex adaptive system, however, system interactions are more complex than a simple stimulus—response model would suggest. The system's GTYPE leads to a particular PTYPE. The resulting PTYPE behavior and structure is either appropriate or not, given the particular requirements of the environment in which the system is embedded. The appropriateness of a particular PTYPE behavior and structure depends on the values attached to critical control parameters that result from the PTYPE. Control parameters maintain, sustain and enhance system survivability and success with respect to environmental requirements. At the same time, the values attached to the control parameters associated with a specific PTYPE behavior affects internal arrangements by forcing the system into the various regimes of behavior. A mismatch between control parameters (PTYPE) and environmental contingencies leads to a modification of the system's GTYPE (alterations of the system's GTYPE through exploitation or exploration). Thus, the GTYPE can be characterized as the mechanism through which system behaviors are controlled – the rules linking system elements provide the system of connections that leads to specific behaviors. The PTYPE behaviors can be characterized as the system's control parameters – the behaviors that link the system to the larger environment and determine whether the system is operating in the stable/static zone, the complex zone, or the chaotic zone. The dynamic processes of CAS are a never ending cycle of altering and adjusting the system's control mechanisms (GTYPE) based on the specific values attached to the system's control parameters (PTYPE). These parameters are significant in relation to *both* environmental criteria *and* internal modalities of behavior (static, complex, or chaotic). A mismatch with environmental contingencies or inappropriate internal behaviors (either static or chaotic) leads to an alteration of control mechanisms through exploitation or exploration – in turn, leading to differing values attached to the control parameters, thus beginning the cycle anew.

Internal/External and Tacit/Overt Schema. Control mechanisms (GTYPE rules) are more generally referred to as internal *schema*. Internal schema may be either *tacit* or *overt*. A tacit internal schema simply prescribes actions based on the implicit necessity of some future state – the action is encoded in the rules governing the interactions of elements. A tacit internal schema governs the behavior of bacterium, for example. An overt internal schema is used as a basis for explicit, but internal, explorations of alternatives. Though internal, these models (or schema) act in an anticipatory manner to enhance the system's ability to deal with future contingencies – resulting in exploration learning – and generally result in changes in the connectivity of the network of connections.

As one moves to "higher" level systems, *external* schema become increasingly important. An external schema refers to a framework that incorporates external factors into the makeup of the connections. Like internal models, external models may be either tacit or overt but they include explicit connections to elements in the environment. Theoretically, because of the non-decomposable, holistic views of reality implicit in the complexity approach, connections between all possible elements (both internal and external) would need to be included in an accurate description of the behavior of any particular system. Unfortunately, because of practical limitations most simulations focus on examination of the implications of internal schema and their affect on system behaviors. The issues concerning control mechanisms will be revisited in Chapter Seven. It seems intuitive to suggest that the mechanisms (rules, laws and GTYPE), though conceptually linked, are fundamentally of a different type in physical, natural and social systems.

Implications of a Connectionist Perspective

The significant point to be made is that connectionism places the emphasis on the connections, rather the nodes or characteristics of particular elements of the system. A connectionist perspective suggests that the essence of behavior and structure result from the connections between the elements of the system, not from the elements themselves. Simulations utilizing these concepts support the notion that highly complex PTYPE behaviors and structures can result from a relatively simple set of GTYPE rules operating on large collections of basic units (Coveney and Highfield, 1995). The system may exhibit a capacity for learning, where adaptation and change is based not on the specific elements that make up the system but rather on the network of connections that link those elements.

This connectionist view creates problems for the traditional reductionist approach to the understanding of system behaviors. From a connectionist perspective (where the importance is on the connection not the element), an understanding of the individual elements (or even the interactions of a limited subset of interactions among elements) can never lead to an understanding of the emergent behaviors of the collectivity. These emergent phenomena (the PTYPE) result from the collective operation of basic rules governing the links between elements (the GTYPE).

Thus, a complex adaptive system can be conceptualized as a network of connected elements where interactions among those elements are based on rules (schema) governing those interactions. Macro-level behaviors and structures result from (emerge) from the multiple and recurring micro-level interactions. A more generalized view suggests that such systems can be seen as (1) a flow of (unspecified) resources through connections linking the constituent nodes of the network where (2) rules (or schema) govern the nature of those linkages or connections. In general terms, the nodes are processors (i.e., they receive input, perform some action, and provide outputs) and the connections indicate all possible interactions between nodes (i.e., they describe all possible paths and direction of flows of input and outputs). The flow of resources through the network varies over time with respect to rate, strength and intensity, and direction. Flows are not fixed in a complex adaptive system, as they are in a mechanical or static system. The changing patterns of connections reflect adaptations as time elapses and experience accumulates. These considerations suggest the nature of the critical control parameters in complex adaptive systems.

Control Parameters in Connectionist Models

The central hypothesis resulting from the study of CAS is that the most successful systems (in terms of survivability, adaptability, and reproducibility) are those that maintain a balance between the forces for stability and inertia and those for chaos and disintegration. That is, those poised on the edge of chaos in Kauffman's (1993) complex region. What determines whether a system is at this edge or not? What criteria or characteristics determine whether a system is in the stable (ordered and frozen) region, the chaotic region, or in the complex transition region between the two extreme zones? Connectionist simulations suggest five control parameters that influence the behaviors of complex adaptive systems: the rate of flows through the system, the density of connections between elements of the system, the strength of connections between elements, the differential degree of influence among individual elements, and the degree of diversity among system elements (Table 5.8).

Rate of Flows. The rate of flow of resources, energy and information has three distinct components:

- Absolute rate of flows through the system.
- Absolute rate of flows in the environment.
- Relative rates of flows between those of the system and those of the environment.

The flow parameter provides the primary temporal mechanism for system behaviors and the primary linkage with the environment. Internal flows of resources, energy and information travel from node to node along the connecting paths that constitute the structure of the system. Evidence suggests that an increase in the rate of such flows tends to increase the degree of instability exhibited by the system. Environments of relatively "slow" flows (i.e., a stable environment) present the system with a comparatively "flat" fitness landscape. This stable fitness landscape allows the system to maintain relatively slow (and easily maintained) rates of internal flows and to traverse the landscape at a moderate pace.

As rates of external flows increase (through the actions and behaviors of other, interacting systems), the fitness landscape becomes "steeper" and results in a need for increases in the rate of internal flows. The increased rates of internal flows are necessary for the system to navigate and respond to the changes in the environment (i.e., exploitative learning must occur). If the system does not respond to this need for increased internal flows and remains frozen in the stable zone, it succumbs to inertial forces and loses the ability to survive the increased turbulence exhibited by the environment. The system must overcome these inertial forces and respond to external contingencies as a requirement for survival. As internal flows increase, however, they become more difficult to "control." At some critical point (a bifurcation or catastrophe), it becomes beyond system capabilities, given the extant structure of connections, to maintain the rate of flow necessary to function successfully. At this critical juncture, the existing structure of connections in the system becomes "overloaded" or "overheated" and is pushed toward instability and the chaotic region. At this bifurcation point, the system must engage in symmetry breaking activities and realign internal connections (i.e., transform internal structural relations by engaging in exploration learning) in order to survive – it must overcome the forces for disintegration.

Density of Connections. Because of positive and negative feedback loops and inherent nonlinearities, CAS are sensitive to the density of connections, or the degree of connectivity between elements, of the system. Less dense networks (i.e., fewer connections) tend to result in more stable systems while a higher density (i.e., more connections) move the system toward instability. A system with very low degree of connectivity is prone to stasis and inertia; a system with an extremely high degree of connectivity is prone to instability and chaos.

Between these extremes is a level of connectivity where the system exhibits enough density to maintain necessary flows, but is not so dense as to encourage unnecessary disruptions. Increased connectivity tends to increase the potential for instabilities because of the unanticipated consequences resulting from inherent nonlinearities. Thus, few connections produce stable behavior and too little variety for learning and adaptation. Many connections produce instabilities and too much variety for effective learning and adaptation. As with the previous control parameters, the effective system is able to maintain a balance between these forces pushing the system in the direction of stability and those pushing the system to chaos.

Strength of Connections. The third control parameter is concerned, not with the *number* of paths of potential interactions, but with the *strength* of those connections. Strong connections set up paths that "canalize" flows through the system (i.e., resources, energy and information are more likely to flow through strong connections than weak connections). Canalization leads to the propagation of fixed behaviors throughout the system and contributes to frozen, static structures.

Such propagation can be simulated in Boolean networks using "canalyzing Boolean functions" (Kauffman, 1993, 1995).[36] These functions can be used to construct networks to ensure orderly, stable behaviors. The effect of such strongly connected networks is twofold. One the one hand, strongly connected networks tend to exhibit more stability and reliability of performance – weakly connected networks tend to instability and redundancy. On the other hand, strongly connected networks tend to result in fixed paths of connections (forced structures) that are generally not as responsive and adaptable as less efficient, though more responsive networks of weakly elements. This, somewhat, reflects the trade-off between efficiency and effectiveness criteria. The "optimum" strength of connections in any particular system is somewhere between the extremely strong (where the positive tendency to stability and reliability is offset by the negative potential for stasis and inertia) and the extremely weak (where the positive potential for adaptability and responsiveness is offset by the negative tendency toward instability and disorganization).

Degree of Influence Differentials. Although many connectionist models treat individual elements of the system as identical, there are suggestions that differential degrees of influence have an effect on system

[36]A canalyzing Boolean function is one that has the property such that the input completely determines the response of the receiving element. The OR function is an example of a canalyzing function. An element regulated by this function is active if *any* of its inputs are active.

behaviors. Kauffman (1993, 1995) suggests that system elements do not all have the same degree of influence in determining system behaviors – some elements contribute more to the overall fitness of the system than others. Additionally, canalization can result in a web of strong connections. Those elements more central to that canalized structure may exhibit more "importance" than other elements simply because of their centrality to patterns of flows. Thus in Boolean networks, any particular element has relatively more influence if its output (the input for the next element) is subject to a canalyzing function (e.g., the OR function). It can "influence" the behavior of the receiving element solely through its own actions (i.e., the presence of its output). The non-canalyzing AND function requires that the output becomes operative only if received in conjunction with other signals. Thus, the "influence" of the sending element depends on additional signals from other elements, not only its own operation. Very "influential" elements tend to attract flows to themselves and the system's behavior is further canalized and stabilized. Such systems tend to result in more "hierarchical" and frozen forms of structure. Systems where influence is relatively equally distributed, on the other hand, tend to exhibit more flexibility and responsiveness, but at the "cost" of a greater potential for instability.

Degree of Diversity. Finally, there is evidence to suggest that differences among individual elements with regard to the diversity of functions and contributions represent a significant control parameter. A system of identical elements – though tending toward efficiency in managing internal flows – may not exhibit the requisite variety necessary for adequate response to pressures for change. Likewise, Kauffman's (1993, 1995) concept of "fitness contribution" suggests that system behaviors depends, in part, on a degree of diversity among individual elements and in the combined contribution of many elements – greater diversity increases the variety of possible responses (effectiveness). However, large degrees of diversity impair the efficiency of internal flows. Should the system exhibit too little a degree of diversity, it may be efficient but tends toward stasis and inertia. Too great a degree of diversity among elements pushes the system toward instability and the chaotic region but may result in more responsive and adaptive systems. At some crucial point between these two extremes, the system has enough diversity to provide learning but not enough to cause anarchy.

Implications

These five control parameters are the most important in determining system behaviors and the structures that emerge from the recurring spatial and temporal interactions among the elements that constitute the system. The first control parameter (rate of flows) regulates temporal behaviors and interactions with the environment. Two of the parameters control the connectivity of the system and the strength of those connections. The final two control parameters concern characteristics of individual elements of the system. These parameters (taken together) determine whether the system is (and remains) in the stable frozen zone, the unstable chaotic region, or at that optimal position between chaos and stasis – the complex region (Figure 5.4).[37]

Conclusions

This chapter (1) describes five of the more significant approaches to the study of complex systems, (2) derives the implications of each approach, (3) compares and contrasts these complexity implications to those of traditional science, (4) argues that the complex adaptive systems (CAS) approach provides a framework to integrate the insights and implications of the complexity sciences, and (5) describes the critical control parameters that determine CAS functioning.

The "complexity sciences" are premised on very different assumptions and foundations from those of the traditional, Newtonian scientific paradigm. Each of the assumptions and implications of the Newtonian worldview described in Chapter 4 have been individually challenged at various times, and by various perspectives, in the history of the sciences. However, the complexity sciences provide the first serious simultaneous and collective challenge to *all* of the traditional assumptions and implications. This is not to suggest that the Newtonian, or traditional, view is "wrong." Certainly, many advances and insights have been, and most likely will continue to be, attributed to this way of

[37] It should be apparent from this discussion that the effects of the control parameters (and their combined effects) on system behaviors can be graphed as a parabolic function of the form $y = ax - ax^2$. As such, the dynamic behaviors exhibited by this relationship may exhibit the properties discussed in the section on the logistic equation. See Figure 5.4.

seeing the universe.[38] At the risk of redundancy, this point must be emphasized: the complexity sciences are best viewed as extensions of traditional science. These new insights and implications do not replace the old; they serve only to enhance and extend understanding.

The complexity sciences do suggest that the Newtonian paradigm provides only a partial view of "reality." Systems are not composed of entirely linear linkages; neither are they likely to be completely nonlinear. Both positive and negative feedback are necessary to explain system behaviors. Not all systems are hierarchically arranged and decomposable through reductionist methods; some may be so complex as to prevent an empirical separation of elements and components, causes-and-effects. Not all system behaviors can be explained by simple aggregation of component elements; some behaviors and characteristics may emerge through the complex interactions of those elements. Not all system behaviors can be explained by equilibrium seeking mechanisms; disequilibrium and periodic instabilities are not inherently dysfunctional and may be necessary features of complex systems.

Systems reflecting the "new" assumptions are characterized as complex adaptive systems. The challenge to researchers attempting to integrate these insights into a particular discipline is to specify how these implications may be best utilized and under what conditions each may apply. This is the problem

[38]After all, scientists and engineers relied on Newtonian mechanics – not Einsteinian relativity – to send the Apollo missions to the moon.

confronting those who wish to explore the issues involved in examining organized complexity. This exploration is central to the complexity sciences and may be the central issue confronting contemporary science. As Kauffman (1993) relates:

> Eighteenth-century science, following the Newtonian revolution, has been characterized as developing the sciences of organized simplicity, nineteenth-century science, via statistical mechanics, as focusing on disorganized complexity, and twentieth- and twenty-first-century science as confronting organized complexity (Kauffman, 1993:173).

Social systems in general, and social organizations in particular, would appear to offer prime examples of organized complexity. It seems reasonable that insights from the complexity sciences should be examined with the goal of furthering an understanding how complex systems, such as formal social organizations, develop and transform over time.

INTRODUCTION TO PART III

"Contrary to the widely held belief that synthesis and mediation between paradigms is what is required, we argue that the real need is for paradigmatic closure...in order to avoid emasculation and incorporation within the <dominant> functionalist problematic."
Burrell & Morgan (1979)

"A synthesis is not possible, since in their pure form the <paradigms> are contradictory, being based on at least one set of opposing assumptions. They are alternatives, in the sense that one **can** *operate in different paradigms sequentially over time, but mutually exclusive, in the sense that one cannot operate in more than one paradigm at any given point in time, since in accepting the assumptions of one, we defy the assumptions of all the others."*
Burrell & Morgan (1979)

"It is impossible to predict the time and progress of revolution. It is governed by its own more or less mysterious laws."
V. I. Lenin

"In war, events of importance are the result of trivial causes."
Julius Caesar

Although the complexity sciences offer a new approach to, and general analytic strategy for, the study of system behaviors, they offer few specific suggestions for empirical content in the social arena. Bartunek (1994) notes that while insights from the new perspectives are "valuable," there is some reason for

> ...concern about the long-term adequacy of the chaos metaphor. It provides intriguing ways of seeing organizational events from a new perspective. However, it isn't clear that the use of the metaphor, without the empirical work that accompanies it in the natural sciences, enables possible disconfirmation of its tenets. Further work that attempts not only

> possible disconfirmation of its tenets. Further work that attempts not only to make use of the chaos metaphor in a variety of circumstances but also to explore its adequacy will be of value (Bartunek, 1994: 337-338).

Bartunek's point is well taken. For the complexity approach to have more than metaphorical or analogical use to social theorists and analysts, a point of contact with the empirical world of organizational phenomena is required to show the perspective's practicality and applicability.

The fundamental premise guiding this effort is, however, that before empirical work can proceed the insights and implications of the complexity approach must be conceptually integrated into the social sciences at a theoretical level of analysis. Armed with such a theoretical perspective, researchers become sensitized to the types of data and methodological strategies necessary and required for empirical testing. Without such conceptual and theoretical development, the "long-term adequacy" remains open to question and it is doubtful that the complexity approach will ever prove more than of metaphorical or analogical use.

An understanding of the processes and mechanisms of organizational change is central to applied management and, thus, presents the fundamental theoretical problem facing organizational researchers. In that the complexity sciences focus on developing explanations of the dynamic processes of system behaviors, a fruitful approach to their introduction into organizational theory is in the consideration of the problem of organizational change, development and transformation.

An adequate theoretical treatment of social and organizational change must incorporate historical, processual and contextual elements. The theory must also offer explanations of the driver, director, source and modality of social and organizational change phenomena. This cannot be accomplished without confronting the issues of the linkages between micro- and macro-level elements and between the objective and subjective features of social existence. Ultimately, these lead to a consideration of the possibility and potential for the prediction and control of social and organizational outcomes.

Part III begins this task by examining the insights and implications of the complexity sciences developed in Chapter 5 at the levels of social metatheory and substantive theory. The metatheoretical arguments in Chapter 6 are framed with reference to Burrell and Morgan's analysis of mutually exclusive worldviews and incommensurate paradigmatic approaches to social theory. Chapter 7 develops an analytical model of organizational change and transformation incorporating elements of the complexity sciences and CAS. This analytical approach extends Turner's (1988) theory of micro-level social interactional processes by linking them to macro-level phenomena through the formulation of a connectionist model of organizational dynamics. The proposed model is used to address the issues of content, driver, director and modality of social system change. Finally, Chapter 8 summarizes the implications of the model, discusses its empirical and methodological implications and indicates future directions for this research agenda.

CHAPTER 6

PREDICTING AND CONTROLLING SYSTEM BEHAVIORS

Attempts to formulate answers to and deal with applied problems are not developed in a vacuum. Theories serve to indicate the manner in which the problems of interest are chosen and defined, the types of evidence and empirical data necessary to support proposed answers and solutions, and the appropriate methods and methodologies for use in the effort. Even ostensibly atheoretical approaches and "trial and error" methods are grounded in an implicit "theory" of significant elements and critical relationships. In turn, theories – either explicit or implicit – are dependent on and guided by metatheoretical, paradigmatic and philosophical assumptions. Because the complexity science offer a set of paradigmatic and metatheoretical implications that differ considerably from those of "traditional" science, a consideration of such issues is a prerequisite to theory development.

Metatheoretical Issues

That there are a multitude of theoretical, methodological, and empirical approaches to the study of social organization and organizational phenomena is a truism that hardly need be noted. More than thirty years ago, in analyses of business school curricula and the state of management theory, both the Gordon and Howell report (1959) and Koontz' (1961) publication of "The Management Theory Jungle" highlighted the diversity of approaches to the study and teaching of management (Wren, 1987). This diversity is evidenced by the many – sometimes seemingly unrelated – problems that management researchers choose to examine, the methods employed in the analyses, the competing vocabularies, and the oft noted "conceptual fragmentation" of the field (e.g., Ranson, Hinings, and Greenwood, 1980; Tsoukas, 1994). This state has engendered two opposing views on the consequences of such diversity. On one side are those who argue that such extreme diversity is detrimental and contributes to the "Balkanization" of organizational science. Alternatively, it is argued that the degree of diversity is overstated and, in reality, organizational studies are subject to the paradigmatic hegemony of realist ontology and positivistic epistemology.

Against Theoretical Diversity

Pfeffer (1993) suggests that, not only has the diversity of theoretical approaches not diminished, such diversity is detrimental to developments in the field of organizational theory and analysis.[1] Such "...theoretical and methodological openness and pluralism...carried to an extreme can be harmful, and given the current climate, downright dangerous" (Pfeffer, 1993: 618). This "dangerous" state of affairs results from the lack of a well defined, generally accepted paradigm by which (1) problems of significance can be identified and (2) the relative merits of competing explanations of organizational phenomena can be judged. This is a significant and crucial issue because:

> The level of paradigm development – technical certainty and consensus – characterizing a field of study has numerous consequences for the social organization and operation of that field...The study of organizations is arguably paradigmatically not well developed, in part because of values that emphasize representativeness, inclusiveness, and theoretical and methodological diversity (Pfeffer, 1993: 599).

A lack of paradigm consensus limits the ability of the field to make scientific progress and reduces its ability to attract resources when competing with adjacent social sciences such as economics. To overcome this limitation the organizational sciences should emulate the fields of economics and political science. In those disciplines, a

> ...consensus was developed by a group of individuals forming a dense network of connections and unified view, who then intentionally and

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[1]Inquiry concerning the problem of paradigmatic diversity is not limited to organizational theory and analysis. The "...theoretical anæmia <of comparative studies of culture> is...an extension of a larger problem in the core discipline of organization theory, viewed by some as directionless and weighed down by useless proliferation (Kochan 1983) and by others (e.g. Sullivan 1992) as polluted by the axiom-based and positivist paradigm espoused by Anglo-Saxon economics is its attempt to cope with its physics-envy" (Redding, 1994: 324). Redding makes his position clear by suggesting that "...there is one central challenge which dominates the field in an epistemological sense and that is the bankruptcy of empirical positivism" (Redding, 1994: 345). The paradigmatic foundations of marketing research have also been subject to "spirited debate." See, for example, Hunt (1991) and Buttle (1994).

> systematically took over positions of power and imposed their views, at times gradually and at times surreptitiously, on the field (Pfeffer, 1993: 619).

Against Theoretical Hegemony

Pfeffer's arguments have been vigorously attacked (Cannella, Jr. and Paetzold, 1994) with the contention that such an imposed consensus would be counterproductive. To "...place control over publication into the hands of a comparatively small elite group who would force a consensus by excluding views that diverge from a dominant paradigm" would stifle the discipline. Consensus by fiat would lead, not to progress, but to an imposed theoretical hegemony and "...the enforced consensus and dominant paradigm called for by Pfeffer would lead to a stagnation in knowledge evolution" (Cannella, Jr. and Paetzold, 1994: 331). Organizational science is "...pre-paradigmatic, in the sense that no one, new paradigm has emerged as a dominant force, distinct from the older, competing paradigms that have been incorporated from the social sciences" (Cannella, Jr. and Paetzold, 1994: 336). Pfeffer argues from an unacceptable paradigm that relies on "...linear cause-and-effect relationships, the linear accumulation of knowledge, technological certainty, and, consequently, a high degree of consensus" (Cannella, Jr. and Paetzold, 1994: 332). This "unacceptable" paradigm stifles research and limits creative approaches to problem solving because "...epistemological validity and progress are seen <solely> in terms of prediction and control" (Redding, 1994:

347). Not only should this state of paradigmatic and theoretical diversity be tolerated, it should be actively encouraged.

The Broader Context

Similar issues and concerns of theoretical diversity are addressed in contemporary sociology (the foundation for much of organizational theory). Specifically, the more general question surrounding sociology's status as a "scientific" discipline, in the sense used to denote the more "mature" physical and natural sciences (e.g., physics), has been scrutinized. On one side of the issue stand the "scientific sociologists" who view "...science as a self-correcting process of knowledge cumulation in which 'the data' ultimately determine the plausibility of general laws" (Fuchs and Turner, 1986: 143). This is the ideal to which sociology must strive in order to be considered a science, on a par with the "mature" physical and natural sciences.[2] The ultimate goal of scientific research is to discover the underlying causal laws governing behavior in order to allow for prediction and control of subsequent events. This goal can only be attained by adherence to the *covering law* or *hypothetico-deductive* model, based on the notion of causal explanation as prevalent in the natural sciences. Causal explanation is understood to imply "...an adequate and justifiable

[2]Those holding to the "scientific" perspective generally have in mind a functionalist, nomothetic, and positivistic approach to problem definition and solution when making their arguments. For example, Pfeffer (1993: 615) relates, with approbation, the paradigmatic development of political science and its move toward emphasis on (1) reductionist, (2) utilitarian, (3) functionalist, and (4) instrumentalist theories. This is taken as a positive sign.

account of <the phenomena of interest's> necessary causes and essential determinants based on the operation of universal laws under specific conditions" (Morrow, 1994: 45).

On the other side of the issue are those (e.g., ethnomethodologists, phenomenologists) who, for a variety of reasons, deny that sociology can be a "science," at least in the sense of the word as used above, because social reality is ontologically distinct from the reality of the physical world and there may be no general laws to discover. Common objections to the transfer of natural science methods to the social sciences include suggestions that the purposes of the two are different and that different purposes require different methods. For example, Strauss (1987: 6-7) argues that "...social phenomena are complex phenomena...<but> much social research seems to be based on quite the opposite assumption" that social reality can be reduced to and analyzed in relatively uncomplex terms (e.g., reductionist, quantitative methods of the natural sciences). The complexity of social reality is temporarily ignored in order to make the phenomena of interest tractable. Moreover, contrary to the supposed value-free natural sciences, social reality (from this perspective) is characterized as value-laden and interactive. All social phenomena are relative, or relational, in a contextual sense (e.g., meanings may vary according to settings; Redding, 1994: 347). For these reasons, attempts to apply "scientific" models and concepts developed to explain physical and natural phenomena to social reality are doomed to failure.

Effects of Competing Approaches

Those adhering to the "scientific" perspective have forwarded two generally held arguments to explain the "immature" or "pre-paradigmatic" nature of sociology (and, derivatively, of organizational theory): first, that sociology is a "young" discipline, relative to the other sciences; or, secondly, that social phenomena are intrinsically more "complex" than natural and physical phenomena. In both cases, the social sciences will become more like the natural and physical sciences given enough time. In the first case, time will allow the social sciences to become more "mature" strictly through a natural developmental process; the natural and physical sciences have had more time to work on their basic problems. In the second case, more time is needed for developments and explanation to emerge in the inherently more complex social world; social scientists have "more things to do" and "more issues to contend with."

Fuchs and Turner (1984) summarily dismiss both views because, in concert with Pfeffer, the state of theoretical diversity is seen to result from a high level of task uncertainty.

> Competing standards of epistemic legitimacy have generated diverse methodological approaches and theoretical orientations. For theorizing in particular, the ***high level of task uncertainty*** helps explain why epistemological and metatheoretical discourses are so prominent in sociological theory since, without an agreed upon paradigm, lengthy epistemological and metatheoretical justifications of a particular approach become necessary (Fuchs and Turner, 1984: 148; emphasis added).

Neither time to "catch up" to (quantitative) developments in the physical and natural sciences, nor time to deal with issues that are (qualitatively) more complex have an affect on this task uncertainty. Only the development of a consensus view on metaphysical, metatheoretical and epistemological issues can alleviate the problem – for "progress" to occur in the social and organizational sciences, all must live under the same paradigmatic roof. Thus, a lack of paradigmatic closure leads to high levels of task uncertainty in the social sciences. In turn, high task uncertainty has resulted in the high degree of theoretical diversity and the lack of progress in the applied disciplines.

While not endorsing Pfeffer's call for the imposition of a dominant paradigm by an academic elite, Fuchs and Turner agree with his general conclusions. For sociology (and, by extension, the organizational sciences) to become more "scientific" and "mature," there is a need for some "...scientific institution...to monopolize control over the production and administration of sociological knowledge" (Fuchs and Turner, 1984: 149). This implies two things: the systematic exclusion of lay audiences as well as competing organizations from "legitimate" discourse; and the monopolization of organizational control over reputational and material rewards.

The Basis of Theoretical Diversity

The basis of these concerns and contentions is what has come to be referred to as the paradigm[3] incommensurability thesis, originally introduced into the philosophy of science by Kuhn and extended by Feyerabend (Hunt, 1991: 41). Paradigm incommensurability was introduced into the organizational sciences with the analysis by Burrell and Morgan (1979). The arguments over the degree and significance of theoretical diversity, at least implicitly, rely on the proposition that differences in fundamental ontological and epistemological stances account for the great range of theoretical approaches to organizational analysis. Further, the incommensurability thesis suggests that an integration and synthesis cannot, and should not, be obtained if the organizational science are to advance.[4] Three conclusions regarding the future of organizational analysis and research are derived from the thesis of incommensurate paradigms:

- *Consensus by fiat*, the imposition of a paradigmatic orthodoxy in order to increase task certainty or, alternatively, to decrease task uncertainty.
- *Maintenance of the status quo*, where competing theoretical and paradigmatic approaches vie in the intellectual marketplace for

[3]Note the difference between Burrell & Morgan and Kuhn on the usage of "paradigm," which Burrell & Morgan use in a much broader sense than Kuhn. In retrospect, Morgan suggests that they would have been better served by using a term such as "world views" rather than paradigm. See especially Marsden (1993: 98-102) and Willmott (1993: 683).

dominance but with the willingness to tolerate, if not encourage, a multitude of approaches in the interim.

- *Encourage efforts to synthesize* the competing approaches and promote the development of an integrating metatheoretical perspective.

The third alternative provides the motivation for the views expressed in this research. The complexity sciences provide an integrating perspective if the focus is shifted to a consideration of the pragmatic results of the competing paradigmatic approaches. To support such a contention requires a brief review of the issues involved in the incommensurability thesis.

Paradigm Incommensurability

Burrell and Morgan state that the central issue and motivating force of *Sociological Paradigms and Organizational Analysis* (1979) was a concern

> ...about the way in which studies of organizational activities had generated mountains of theory and research which seemed to have no obvious links outside narrow discipline areas...about the essentially ephemeral nature of <the> subject...<and> about the academic sectarianism reflected at various times in open hostility, ostrich-like indifference and generally poor-quality dialogue and debate between essentially related schools of thought (Burrell and Morgan, 1979: xi).

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[4]Pfeffer's arguments seem to imply either that paradigms are truly incommensurate and no synthesis is possible or that such a synthesis is too difficult for organizational theorists to attempt.

These concerns led to an examination of why there are so many theories of, and about, organizational phenomena.[5] The conclusion reached in *Sociological Paradigms* was that the plethora of theoretical approaches results from the fact that all theories of social phenomena are based upon, first, assumptions about the nature of social science and, secondly, on assumptions about the nature of society and the social world. Metatheoretical assumptions and presuppositions in these two areas, either explicit or implicit, fundamentally determine the problems chosen for study and the theories, models and methods developed to "explain" the phenomena of interest. The next sections briefly review the arguments presented by Burrell & Morgan (1979) and those of Tsoukas (1994), who offers a complementary (but somewhat divergent) framework in an analysis of similar issues.

Burrell and Morgan

In the Burrell and Morgan scheme, theories on the nature of science coalesce along a subjective-objective axis and theories of society along a regulation-radical change dimension. Assumptions about these metatheoretical issues result in four elementary paradigms (Radical humanist, Radical structuralist, Interpretive, and Functionalist: Figure 6.1) which offer mutually exclusive views of the social world. Constitutive issues of the subjective-

[5]See Gioia and Pitre (1990), Jackson and Carter (1991, 1993), Hassard (1988, 1991), Parker and McHugh (1991), Marsden (1993), Willmott (1993), Redding (1994), Weaver and Gioia (1994) and Schultz and Hatch (1996), among others, for arguments for and against paradigm incommensurability.

objective dimension relate to assumptions concerning ontology, epistemology, methodology, and human nature. Issues central to the regulation-radical change dimension relate to alternative conceptualizations of social stability/change, integration/conflict, coordination/integration, and consensus/coercion.

Subjective Versus Objective Approaches To Social Science. The subjective-objective dimension emphasizes basic differences in approaches to, and understanding of, the nature of science and scientific explanation. Such differences are grounded in the researcher's fundamental conceptualization and understanding of "reality" (Figure 6.2). The position taken by the researcher (or theorist) on the ontological status of "social facts" (to use Durkheim's term) is central to the specification, or statement, of problems involving efforts to describe or understand social reality. The ontological position fundamentally defines the researcher's conceptualization of the constitution of social reality and, thus, serves to identify appropriate subjects of inquiry, substantive issues worthy of attention, and appropriate methods of demonstration and "proof." Essentially, the ontological question revolves around whether social reality can be reduced to properties of individuals and their subjective interpretation of personal experience (*social nominalism* – "reality" an internal product of individual consciousness), or whether there are characteristics of collective units which are somehow "more" than, and external to, the aggregation of subjective interpretation (*social realism* – "reality" is external to the individual consciousness).

From a nominalist perspective there is no "real" structure to the external world, beyond the names, concepts and labels used to interpret and structure individual reality. Reality is socially constructed by individuals through "symbolic" interaction with others and through the dialectic between social interaction and individual existence (e.g., Berger and Luckmann, 1966; Baldwin, 1986). The realist position, on the other hand, "...postulates that the social world external to individual cognition is a real world made up of hard, tangible and relatively immutable structures" (Burrell & Morgan, 1979: 4). Carried to an extreme, the ontological position which champions a nominalist approach leads to a Berkelian solipsism and allows for no external constraint on an individual's self-determination and "free will." At the other end of the dimension, an extreme realist position seems to imply a social determinism, in which the individual's fate is determined by the social structure (and the laws which govern relationships between structural components) in which s/he is imbedded.

Closely related to the ontological issue is the epistemological and methodological orientation taken by the researcher. Researchers who view society from a position of social realism would be inclined to search for causal laws to explain the relationships between social units (a positivistic and nomothetic approach).[6] This, in turn, implies a related determinism – social behavior is, at least partly, a result of general underlying social (natural) laws and not the result of individual free-will. Alternatively, researchers more inclined to a nominalist position, view social facts (events, things, or individuals) as unique or socially constructed occurrences, would be more receptive to an "antipositivist" epistemology and tend to employ ideographic methods (Figure 6.2). This position implies a free-will, or voluntaristic, assumption about human nature.

Readers requiring a more in depth exposition of these issues are referred to Burrell & Morgan (1979). The point emphasized here is that these two sets of assumptions define paradigmatic approaches that reflect quite separate and distinct views of social reality. Because of the fundamental nature of the philosophical issues, the approaches cannot be integrated and, further, such a synthesis *should not* be attempted. The four fundamental paradigms are "...in essence distinct, internally coherent and self-sustaining" (Burrell and Morgan, 1979: 396). Rather than attempting a fusion and synthesis of the approaches, more effort should be given to tracing and developing the perspectives from within the philosophical traditions from which they derive. This paradigmatic apartheid serves as a defense against "scientistic

[6]The belief that contemporary social science is dominated by positivism is a "consensus position" according to Hunt (1991: 32 – see note 1). However, note that it is possible to espouse a realist ontology but disagree with the positivistic epistemological position (see Tsoukas, 1989, for example).

authoritarianism" (Jackson and Carter: 1991) and, through paradigmatic closure, avoids "...emasculation and incorporation <of the less widely accepted approaches> within the <dominant> functionalist problematic" (Burrell & Morgan, 1979: 398). This is the basic premise of the incommensurability thesis.

The Order/Radical Change Dimension. The second dimension of the Burrell and Morgan framework differentiates theoretical perspectives on their fundamental approach to the problem of social change. Alternative approaches focus either on "explaining the nature of social order and equilibrium on the one hand" or on "problems of change, conflict and coercion in social structure on the other" (Burrell and Morgan, 1979: 10). These form the basis of the order-conflict debate in sociological theory: How do social entities remain stable, yet change over time? Conversely, how do systems that have the potential for so much disintegration and conflict ever achieve the order we observe?

Many sociologists (at least at the time of publication of Sociological Paradigms) viewed this debate closed and that order and conflict are best viewed as two sides of the same coin (e.g., Cohen, as reported in Burrell and Morgan, 1979). Sociological Paradigms reopened the controversy, however, with an examination and review of the intellectual source and foundations of the debate. Following arguments put forth by Dahrendorf, the opposing views are described as:

> *The integration theory of society*, as displayed by the work of Parsons and other structural-functionalists, is founded on a number of assumptions of the following type:
> (1) Every society is a relatively persistent, stable structure of elements.
> (2) Every society is a well-integrated structure of elements.
> (3) Every element in a society has a function, i.e., renders a contribution to its maintenance as a system.
> (4) Every functioning social structure is based on a consensus of values among its members...
>
> ...*The coercion theory of society* can also be reduced to a small number of basic tenets, although here again these assumptions oversimplify and overstate the case:
> (1) Every society is at every point subject to processes of change; social change is ubiquitous.
> (2) Every society displays at every point dissensus and conflict; social conflict is ubiquitous.
> (3) Every element in a society renders a contribution to its disintegration and change.
> (4) Every society is based on the coercion of some of its members by others.
>
> (Dahrendorf, 1959: 160-162; quoted in Burrell and Morgan, 1979: 12).

Thus, the "integration theory of society" or the "sociology of regulation" is primarily concerned with providing explanations of social phenomena that emphasize their underlying unity and cohesiveness (Table 6.1). The focus is on why (and how) social structures, in the face of disintegrative forces, tends to "hold together rather than fall apart" (Burrell and Morgan, 1979: 17). Durkheim's emphasis on the nature of social cohesion and solidarity in his discussion of the importance of the division of labor is a prime example of this type of theory.

In opposition stands the "coercion theory of society" or the "sociology of radical change" which is centrally concerned with issues of radical change, structural conflict, modes of domination and structural contradiction which, from this view, are seen to dominate society (Table 6.1). Marxian analysis is a prime exemplar of this approach. The central concern is how, in the face of overwhelming inertial forces and the strength of the *status quo*, does society ever advance (or change). The process of social change and development is viewed not as an evolutionary process which develops gradually and incrementally but as a dialectical process of revolutionary and abrupt episodes of radical change punctuating lengthy periods of relative stasis and inertia dominated by differing segments of society.

An Alternative Framework: Tsoukas/Pepper

Tsoukas (1994), building on Pepper's (1942) *World Hypotheses*, offers a similar framework but focuses specifically on ontological and epistemological issues and emphasizes the "...different approaches to obtaining formal knowledge in management studies" (Tsoukas, 1994: 761). From Tsoukas' perspective, the more significant of the two dimensions in the Burrell and Morgan framework is the subjective-objective dichotomy. The regulation-radical change dimension is more appropriately, in Tsoukas' view, conceptualized as an inherent property of the social theories themselves rather than as metatheoretical assumptions about features of the social world. Tsoukas thus posits two dimensions (analytic versus synthetic theories, dispersive versus integrative theories) which account for the various approaches to knowledge generation in organizational theory (Figure 6.3).

Analytic theories are those where "...complexes or contexts are derivative, not an essential part of categorization" and where "...discrete elements or factors, not complexes or contexts" are considered significant and important (Tsoukas, 1994: 763). Analytic theories are essentially reductionist: by understanding the behavior of components of a system, and their relationship to other components, one can infer an understanding of the whole. The content of the phenomena of interest is important, all else (the "complexes and contexts") is epiphenomenal.

Synthetic theories, on the other hand, are essentially holistic. The whole or pattern (a *gestalt*) is taken as the object of study, rather than a set of discrete facts or components of the phenomena. From the perspective of synthetic theory, one *cannot* understand the whole by looking at components in isolation. This synthetic/analytic dimension is primarily concerned with the nature of the object of study (i.e., what is more significant, the part or the whole?) and reflects the differences between holistic and reductionist approaches to the study of social phenomena. Thus, given the "what" of social reality (the part or whole), it addresses the question of how (the "means") knowledge of organizational phenomena are generated (reductionist or holistic methods).

The second dimension (dispersive v. integrative theories) concerns the objectives, goals, or "ends" of the explanation (i.e., what is the theory trying to accomplish?). *Dispersive theories* "...seek to capture similarities and differences...without being necessarily concerned to offer an account of the underlying mechanisms" responsible for the observations (Tsoukas, 1994: 763). From this perspective, "...the multitudes of facts it seeks to register are assumed to be loosely structured, not systematically connected by virtue of a lawful relationship" (Tsoukas, 1994: 767). *Integrative theories*, however, view the world as well-ordered, determinate and ultimately predictable. These approaches attempt to account for this underlying order through the discovery of the laws (the underlying nomothetic, "causal" structure) governing observed behaviors.[7]

Dispersive theories are primarily descriptive in nature; the goal is to describe or classify observations of reality. Integrative theories have prediction as the primary objective. Thus, this dimension reflects a concern with the appropriate "ends" of organizational research, whether the goal is one of understanding and description or, alternatively, prediction and control.

These four perspectives are combined to generate four approaches to generating formal knowledge: *formism*, *mechanism*, *contextualism*, and *organicism* (Figure 6.3).[8] Conclusions, based on this framework, echo the Burrell & Morgan claims for paradigm incommensurability. Tsoukas contends that these "...world hypotheses are epistemologically incommensurate – one

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[7]See Allen's (1988, 1994) discussion of taxonomic rules for describing the components of a system of interest (classifying objects according to differences and similarities) and the rules governing the interaction among components (causal linkages between objects comprising the system). Compare this to Tsoukas' distinction between dispersive and integrative theories.

[8]A description of each of the four approaches does not have a direct bearing on the points of interest to the analysis pursued here. Again, the reader is referred to Tsoukas (1994), and to the bibliography, for a more detailed treatment of these issues.

cannot reject one on the basis of another and, thus, they cannot be synthesized into an overarching world hypothesis" (Tsoukas, 1994: 763). Thus, both Burrell & Morgan and Tsoukas argue that fundamental paradigms and worldviews are incommensurate because of the basic antithetical nature of the assumptions underlying each view.

Significance of the Incommensurability Thesis

Paradigm incommensurability has not been entirely accepted in either the social sciences or the philosophy of science. For example, Hunt (1991) notes that "...because paradigm incommensurability seemed to imply relativism, irrationalism, and nihilism, it became one of the most thoroughly investigated topics in the philosophy of science" (Hunt, 1991: 41). Based on a review of the arguments for and against incommensurability, Hunt concludes that the thesis "...has been so thoroughly discredited in philosophy as to be virtually abandoned by Kuhn...<and> poses no difficulty for science."[9] However, to conclude that the various paradigms are not "logically" incommensurate does not mean that, in practice, the opposing perspectives do not lead to theoretical diversity. Further, even if opposing paradigms *can* be shown commensurate, that still does not the address the contention that a synthesis *should not* be attempted. As noted above, a major defense of paradigm incommensurability is

[9]The reader is referred to Hunt (1991) for further development of this subject and citations used to support his arguments.

that it allows for more diversity of research effort and openness to new approaches (the state that Pfeffer deplores).

The point, however, is not to argue for or against a particular ontological, epistemological or methodological position, or to submit an offer of "proof" supporting one paradigmatic position or the other, or even to argue for or against the incommensurability thesis as developed in the preceding paragraphs. Rather than consider these issues at the level of philosophical or metaphysical discourse, the approach taken here is more limited and addresses issues that are more pragmatic. The concern is to examine the practical and implications of diverse paradigmatic approaches particularly as they concern the basic goals and objectives of research programs. A focus on the pragmatic implications of paradigmatic diversity suggests the following specific questions: What are the "realistic" or "practical" goals and objectives of organizational science? What are the results for which organizational researchers can, and should, strive?

Goals and Objectives of Social Research

These questions confront the issue of whether the ultimate goal of social science is one of prediction and control, or whether the best that social science can hope to attain is a deep understanding of social phenomena. Are prediction and control are beyond the scope of the social sciences? These questions are clearly related to two basic research traditions in the social sciences: *quantitative* versus *qualitative* methodologies.

The reformulation of social science questions according to the demands of statistical (quantitative) techniques followed from Newton's successes in explaining natural phenomena.[10] This reformulation was initially encouraged to offset an even longer tradition in the social sciences of preferring "big" questions and comparably broad empirical generalizations based on qualitative methodologies (Artigiani, 1987; Ragin, 1987; Camic and Xie, 1994). However, many now argue that the pendulum has swung too far to the reductionist and quantitative/positivistic pole resulting in a view that if a problem or concept cannot be operationalized and quantified, the phenomena is not of interest. Reductionist (or analytic theories in the Tsoukas framework) scientific methods have led to many discoveries and breakthroughs. However, reductionist and positivist approaches may be entirely inappropriate in the examination of complex phenomena because many of these phenomena result or emerge only through the complex interactions among and between system components when taken as a whole.

What is needed to redress this state is a holistic approach (Tsoukas' synthetic theories). However, even studied holististically, the complexity sciences suggest that it may be theoretically and inherently impossible to attain the goal of making valid predictions which is, in the view of Collins (1995), the

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[10] This refers to the process of "scientization" of social dynamics as discussed in Chapter 4.

goal of a mature social science. Rather than focusing on prediction (i.e., Tsoukas' integrative theories), this suggests that social scientists should begin to focus more (or perhaps refocus) on interpretation and understanding (as in Tsoukas' dispersive theories). As Kuran (1995) notes:

> There exist theories that predict better that they explain. For example, the Ptolemaic theory of the universe is quite successful at predicting the movement of planets, but by modern standards its explanation for these movements is very inadequate (Kuran, 1995: 1536f).

Explanation versus Understanding

The difference between these two goals are reflected in the terms *Erklären* and *Verstehen*, which are linked with the differences in explanation between the natural (*Naturwissenschaften*) and the cultural sciences (*Geisteswissenschaften*). *Verstehen* is a German "...term that comes from the verb meaning 'to understand' and refers to the processes of meaning interpretation required for communication. As such it overlaps with the methodological issues of *hermeneutics* or the interpretation of texts" (Morrow, 1994: 93-94). From the metatheoretical assumptions of the subjectivist position, *Verstehen* (or interpretation) is seen as the only realistic goal of social science and "...natural scientific causal explanation is rejected as inappropriate for understanding human action" (Morrow, 1994: 93-94). *Erklären*, on the other hand, "...means 'explanation' in the natural scientific sense of causal explanations based on invariant (*nomothetic*) laws associated with both hypothetico-deductive and covering law models" (Morrow, 1994: 93-4).

Discovery of such laws should ultimately lead to an ability to predict and control the behavior of the phenomena of interest. This reflects the goal of the objectivist position. This distinction is also suggested in Tsoukas' notions of dispersive (descriptive) and integrative (predictive) theories.

A Pragmatic View

Thus, in terms of what is *pragmatically* expected – with regard to explanation and understanding in the social sciences – the Burrell & Morgan subjective-objective dimension (and, similarly, the Tsoukas dispersive-integrative dimension) can be reconceptualized as a prediction/control[11] versus understanding dimension (Figure 6.4). Figure 6.4 is meant to suggest that the two modes of explanation and understanding exist on a continuum. They represent, not dichotomous and unrelated viewpoints, but issues that each have a role to play in the understanding of complex social phenomena. Neither approach is likely to offer a complete and satisfactory description of social reality. However, the extremes of the continuum do represent the practical and pragmatic consequences of the philosophical and metatheoretical dichotomies outlined above. It should be clear that the term pragmatic in this context refers not to the common notion of pragmatism where choices are made on the basis

[11] *In re* prediction in the social sciences, see the report on the *Symposium on Prediction in the Social Sciences* (introduced by Hechter, 1995) as reported in the American Journal of Sociology (Vol. 100, No. 6, 1995). Includes articles by Hechter, Kuran, Collins, Tilly, Kiser, Coleman, and Portes. The series of articles address specifically the question of whether prediction (and, thus, control) is attainable in the social sciences.

of "...any practical, hard-nosed, matter-of-fact viewpoint...based on practicality or expediency" (Baldwin, 1986: 14) but to the philosophical pragmatism of Pierce, James, Dewey and Mead. This more formal notion of pragmatism holds that the "meaning" of an intellectual conception or proposition lies in its logical or physical consequences.

The practical implications of the subjectivist/objectivist dichotomy (and the incommensurability thesis) are its logical consequences for the issues of interpretation/*Verstehen* (understanding) versus explanation/*Erklären* (prediction and control). Reformulation of the dichotomy into a continuous dimension reflects, taking as given the metatheoretical and philosophical assumptions of the respective positions, differences in the expectations of social science and organizational research.[12]

Reformulation of the objectivist versus subjectivist approaches in terms of the pragmatic expectations concerning long-term prediction and control versus understanding provides a link to the complexity sciences. One of the central implications of the complexity approach is that the twin goals of prediction and control may be *theoretically* impossible (or at least, severely limited) in any domain of scientific inquiry (see, for example, Smith, 1995).

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[12]The issue of incorporating both modes into a description of social system behaviors is addressed in Chapter 7.

The Complexity Sciences

Implications (Table 6.2) from the complexity sciences suggest that – because of sensitivity to initial conditions, inherent nonlinearities, positive feedback, self-reference and recursiveness – complex adaptive systems exhibit emergent behaviors that make prediction impossible except, perhaps, for the very near term. This is in spite of the fact that components of these systems are connected in a nomothetic structure of deterministic laws and rules. Even if these laws, or rules, are completely known and specified, the long-term behavior of the system cannot be predicted. As Stacey (1996) notes, the view of social organization as a nonlinear feedback system implies that

> Causal links between specific actions and specific organizational outcomes over the long term disappear in the complexity of interactions among people within an organization and across its borders with other organizations...<but that> because nonlinear feedback networks are the product of their precise history and because it takes time for small changes to escalate in such systems, their short-term behavior is predictable (Stacey, 1996: 214).[13]

Discovering the temporal limits to predictability is a prime area for research into a perspective of social organization as a complex adaptive system with emergent properties. However, the point to emphasize is that to the extent that these insights on predictability and control apply to social systems, both the

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[13]The issue of the limits to predictability was introduced in Chapter 5. See Bak *et al.* (1988, 1991) for the distinction between weak and strong forms of chaos and their implications for the limits of predictability. See also Ford (1983) on this subject. A specification of the limits to predictability is an issue of central importance and of some dispute in the complexity literature.

objectivist and subjectivist positions can be considered the "true" state of affairs. Certainly, this area deserves further examination.

Social systems, in fact, may be governed by a nomothetic structure of deterministic "laws" (an objectivist/positivistic/nomothetic argument). However, the effect of these laws is to generate unpredictable, emergent and seemingly random behaviors that make long-term prediction and control inherently impossible (a subjectivist/voluntaristic/ideographic position). Thus, even if there is an underlying and fundamental nomothetic structure to social reality, prediction and control may be beyond the ability of social science. Alternatively, just because prediction and control may be unattainable does not negate the possibility of such a nomothetic structure.

Recasting the dimensions of the incommensurability thesis in terms of the pragmatic and practical results expected of organizational analysis is at the core of what the complexity sciences are contending with in examining complex physical and biological systems. The fundamental complexity science implication for the social sciences is that the issues underlying objective versus subjective approaches may not be as dichotomous, or as paradoxical and contradictory, as appearing at first glance. In fact, these issues may represent two sides of the same coin or two aspects of the same general underlying process. While a resolution of the metaphysical issues is not offered in any ultimate sense – indeed, like arguments about the existence and nature of God, the issues may be ultimately irresolvable – the complexity sciences shed light on the pragmatic issues involved. Thus, the complexity sciences offer an opportunity for a pragmatic and practical resolution of metatheoretical and philosophical issues outlined in the first sections of this chapter.

Beyond arguing that the complexity sciences provide a way of resolving such issues by linking subjective and objective approaches, the complexity sciences suggest that the order-conflict dichotomy is also misleading. Emerging insights into the behaviors of complex systems "...erode the distinctions between order and chaos, stability and change, being and becoming" (Baker, 1993: 123). Order and chaos (stability and change) are perhaps best conceptualized, not as irreconcilable opposites, but as dimensions of the same process. Reality can be as readily viewed as fundamentally "...stable with intermittent interruptions of change or as changing with intermittent interruptions of stasis" (Baker, 1993: 123). These follow from the notion of social organization as nonlinear, recursive, self-referential complex adaptive systems.

Conclusions

Either explicitly or implicitly, issues of predictability and control are central to many, if not most, social researchers. This is particularly true for researchers engaged in the applied social disciplines and who conduct their research within the confines of business and professional schools. Inherent unpredictability has long been attacked from the basis of the indeterminacy of history (see Hechter, 1995). This attack has been led by those espousing a generally subjectivist position. However, the notion of predictability is being increasingly attacked from within the objectivist position by the emerging complexity sciences. Noted complexity theorist Stuart Kauffman (1995) makes the point:

> We confront here the distinction between explaining and predicting...Our final theory of physics might well explain but certainly will not predict in detail...both practical and quantum considerations preclude such a possibility. Thus the familiar conclusion: for chaotic systems, we cannot predict long-term behavior. Note again that failure to predict does not mean failure to understand or to explain. Indeed, if we were confident we knew the equations governing a chaotic system, we would be confident we understood its behavior, including our incapacity to predict in detail its long-term behavior (Kauffman, 1995: 16-17).

Roll (1988) makes a similar point when commenting on the immaturity of the "financial sciences" as gauged by the conspicuous lack of predictive content about some of the discipline's most interesting phenomena. The financial sciences "...can boast about very high explanatory power if the phenomenon is artfully selected" but examples of this level of predictability "...are analogous to a meteorologist who might claim a high degree of predictive power because the weather can be forecast fairly accurately over the next hour" (Roll, 1988: 541). This statement is even more relevant to the degree and level of predictive power in organizational theory. A central proposition of the complexity sciences is that the degree of predictive power of any science is limited but that such limitations are not due to the limitations of science and scientists. Rather such "limitations" are a fundamental property of complex systems.

It may be that the complexity sciences will emerge as the "dominant force, distinct from the older competing paradigms" that Cannella and Paetzold (1994: 336) see as yet forthcoming. However, it appears that the goal of predictability and control must be abandoned. This eventuality should not be taken as a cause for despair among social and organizational theorists -- satisfactory explanation may be possible even if prediction of the future is not (Scriven, 1959). The task of understanding provides more than enough challenge for many generations of theorists.

The major claim being made here is that the complexity sciences offers a perspective developed from an objectivist/positivistic/nomothetic paradigm, but that the *pragmatic* implications of the complexity perspective are similar to those of the *pragmatic* aims of researchers espousing a subjectivist/anti-positivist/ideographic position. In this sense, the complexity sciences may render the issue of paradigm incommensurability moot as a practical issue for researchers in the organizational and social sciences. The search for nomological relationships between organizational elements is a valid goal for organizational theorists. However, the discovery and understanding of these relationships does not negate the need for examining the temporal processes of organizational phenomena in historical context, without any assurance of ultimate predictability and control. Likewise, those approaching social problems from a subjectivist position should note that the complexity sciences point to the possibility of an underlying nomothetic order, or deep structure, that can account for the apparent unpredictable and complex behaviors observed in everyday organizational life. The complexity sciences point, not an either/or view of disparate paradigms, but to a both/and perspective. Thus, the complexity sciences may offer an answer to the question posed by Daft and Lewin (1990) of whether or not organizational studies can begin to break out of the "normal science straightjacket" by providing a way of viewing social realities that link the subjective to the objective.

CHAPTER 7

TOWARD A CONNECTIONIST THEORY OF ELEMENTS AND INTERACTIONS

ORGANIZATIONAL DYNAMICS

Viewing social systems as examples of CAS promises a new approach to conceptualizing and describing dynamic organizational processes. However, to suggest that social organizations are inherently nonlinear and complex – and that organizational researchers must revise their worldview (i.e., a "paradigm shift" must occur) to take these insights into account – offers little in the way of specific guidance for theorist, researcher, or practitioner. For the CAS approach to have any relevance for organizational science (either at the theoretical, empirical or applied levels of analysis), these complexity science insights must be incorporated in such manner as to enhance current understanding of organizational phenomena. The purpose of this chapter is not to propose a *new* approach but rather to *integrate* the implications developed thus far into a theoretical approach to organizational developmental and transformational change processes. This suggests the purpose of establishing points of theoretical intersection between the CAS approach and contemporary approaches to the study of social system behaviors. This integrative effort is approaches to the study of social system behaviors. This integrative effort is addressed within the context of the complexity implications developed in Chapter 5 and the paradigmatic issues raised in the previous chapter.

Need for an Integrative Metatheory

Subjective—Objective Integration

Arguments presented in Chapter 6 suggest that both subjective and objective (*Verstehen* and *Erklären*) approaches to the study of social phenomena may be "right" given that alternate views on the potential for prediction and control are the pragmatic results of the underlying metatheoretical issues. Implications from the complexity sciences – and the CAS approach – suggest that (1) even it there is an underlying nomothetic structure to "reality" and (2) the laws can be discovered and specified, prediction and control over any meaningful or relevant timeframe may still be a theoretical and practical impossibility.

On the other hand, just because prediction and control may be theoretically impossible (because of either the presumed intentionality and free-will of individual actors or historical indeterminacy) does not mean that there are no such laws. The unpredictability may result, in fact, from underlying deterministic processes. The pragmatic result, from either an objectively based nomothetic or a subjectively based ideographic perspective, is an inherent unpredictability at least over a time frame of any sufficient magnitude. A contention that neither a subjective nor objective approach is entirely "correct," however, implies a need for a perspective that integrates both the subjective and objective features of social life and provides a method of linking the two.

Macro—Micro Integration

An inextricable element of the metatheoretical and paradigmatic debates is the issue of holism versus individualism (i.e., reductionism). Implicit in an objectivist and nomothetic worldview is the notion that "reality" can be apprehended in a piecemeal fashion and disparate phenomena analyzed in isolation. Alternatively, a subjectivist and ideographic approach suggests that phenomena can be understood only in their totality relative to other phenomena and with regard to specific historical and contextual factors. This part/whole dichotomy has found expression in the organizational sciences as the macro-micro debate and the issues involved in interactions among levels of organizational and social phenomena.

These concerns suggest a need for a research agenda that addresses the mechanisms and processes through which micro-level phenomena affect, and are affected by, macro-level structures. Such an agenda would focus on the development of models and theories explicitly incorporating the hierarchical structuring of social systems and examine – beyond interactions among components at the same analytic level – linkages and interactions between entities, elements and phenomena at multiple levels. Multi-level research is required for a better understanding of the processes by and through which organizations and social systems evolve, develop and transform (Long, White, Mathews and Peiperl, 1999).

Models and Methods

Attempts to develop process models of organizational change processes that incorporate contextual and historical effects force organizational researchers to confront the issues of linkages between the subjective and objective, the macro and the micro. Efforts to integrate the complexity sciences into organizational studies with the goal of describing the drivers, directors, sources and modalities of developmental and transformational processes must, of necessity, incorporate these concerns into such models. This is particularly true if the goal is to illustrate how a complexity approach can extend and enhance current understanding of social phenomena.

The next section reviews the issues involved in the holism-individualism debate and links these issues to the problem of hierarchy and the macro-micro debate in the social sciences. The effects of these issues are related to several contemporary approaches to the definition and specification of organizational processes. A second section outlines the complexity science perspective on the problem. Turner's (1988) dynamic theory of social interaction is posited as a point of intersection between the complexity approach to CAS (complex adaptive systems) and the behavioral sciences. A third, and final, section develops an analytical model of social organization that provides the foundations for a connectionist theory of organizational dynamics. This connectionist perspective suggests a method of conceptualizing organizational phenomena that links the subjective to the objective and macro to micro.

Macro—Micro Linkages: Heterarchies and Holons

Because of the complex and multidimensional nature of social and organizational phenomena, specific components of interest and the processes accounting for dynamic behaviors in these phenomena vary from researcher to researcher. This has the practical result of restricting explanation to carefully limited and delimited areas – and to an implicit, it not explicit, reductionist position. This reductionism, in large measure, is a reflection (though not a necessary requirement) of the nomothetic worldview implicit in the deterministic and positivistic realism of the objectivist approach to social science. A reductionist strategy is generally acknowledged as reasonable in that "reality" is too complex to be tractable – reality must be "broken down" into to its constituent components to be understood. Thus, most theories in the organizational sciences are couched at a specific and carefully delineated level.

The Need for Multi-level Research

However, there have been recent calls for multi-level research that examines connections between variables at the micro and macro levels of analysis (Long *et al.*, 1999; House, Rousseau and Thomas-Hunt, 1995; Capelli and Sherer, 1991). Because of the multidimensionality of organizational reality,

> ...organizational phenomena are much too complex to be described by any single theoretical approach. Current research on organizations could benefit greatly if researchers were to pay closer attention to specifying the *points of intersection of different theoretical perspectives* and to combine these perspectives to provide more complete explanations of the behaviors they study (Tolbert, 1985: 12; emphasis added).

While Tolbert is not specifically addressing the macro-micro issue, the argument applies -- an adequate treatment of change dynamics in complex systems must explicitly consider the points of intersection between multiple levels of phenomena.

A central tenet of the arguments developed in Chapter 5 is that, from the Stage Three complexity science approach, system behaviors can *only* be understood holistically. Reductionist methods (which have predominated in the organizational sciences) can never hope to offer anything more that a partial, and potentially mistaken and misguided, view of complex system behaviors.

Traditional Research Programs. In order to understand change processes at any particular level implies a need for the development of "dynamic theories and process hypotheses" and a need for longitudinal research designs in order to test these hypotheses (Monge, 1990: 406). The "traditional" approach to researching organizational phenomena begins with the construction of a reduced-form model of some aspect of social reality. This model focuses on the key components affecting the focal construct (usually at one level only) and a specification of hypothesized relationships between these components – a theoretical causal hypothesis is established (see Allen 1988, 1994). As Stacey (1995) notes:

> The dominant frame of reference for research in management and organization is the reductionist one of testing hypothesized connections between a specific cause, usually in the environment, and a specific effect, usually in a part of the organization being studied (Stacey, 1995: 492).

Data are then collected to "test" whether or not the hypothesized relationships are supported by empirical observation. To the extent that the hypotheses are "supported" by the data, the model is provisionally accepted (though always subject to refutation and modification by new data). This evidence is used to formulate a general theoretical model and the attempt is made to apply the model to similar experiences and situations.

In such research programs, the focus is clearly on the "content" of the problematic (i.e., the spatial behavior of the system of interest), not in its temporal behavior (i.e., how the system changes over time). This traditional approach is essentially a strategy of *categorization*, constructing a reduced form model of complex reality (what Allen, 1988 refers to as "taxonomic classification") and *correlation*, proposing and testing linkages among the components of the model ("spatial aggregation" per Allen). These correlations between constructs are then generalized to other systems of interest (e.g., other organizations).

While the methods of categorization, classification and correlation are useful and necessary starting points to any theoretical construction, they are just that: a beginning. However, such "...static typologies do not easily allow for the analysis of processes" (Turner, 1988: 10). Further, if the interest is on coming to grips with the invariant and generic elements of organizational dynamics, insights from the complexity sciences suggest not only the necessity of utilizing longitudinal or diachronic data but also the necessity of including multiple levels of phenomena in the analysis.[1]

Structure/Action and Part/Whole Dialectics. Similar issues prompt Astley and Van de Ven (1983) to argue in terms of two distinct and opposing forces central to an understanding of organizational dynamics: structure/action dialectics and part/whole dialectics. The first of these sets of forces (structure/action) focuses on how activities and actions are translated over time into observed and experienced social structures and, conversely, how those structural arrangements serve to limit and constrain individual actions and activities. The second set of forces (part/whole) focuses on the relationships, and interrelationships, between levels of phenomena and

> ...to properly study organizations across levels of analysis is to understand the dialectical relations between forces of conflict, coercion, and disruption at one level of organization, and forces of consensus,

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[1]To reiterate a point made earlier, it must be emphasized that the argument is not that traditional science is "wrong" or that the tools and techniques of the scientific method are irrelevant to the study and understanding of practical and applied problems. To the contrary, most of our knowledge has been generated with such methods. The argument is, however, that "traditional" science (i.e., relying on the assumptions developed in Chapter 4) is limited in several respects. The complexity approach attempts to overcome those limitations and offer a more complete explanation of dynamic phenomena.

> unity, and integration at another level – forces that are prerequisites and reciprocals of each other (Astley and Van de Ven, 1983: 269).

Although most social researchers work from either a macrosocial or a microsocial perspective, the two are perhaps best understood as complementary processes (Scott, 1990). Empirical integration of macro and micro dynamics, however, has proven difficult because the interactions of micro and macro forces may be observable only over long periods of time, possibly years or decades. Further, even though the broad outlines of how macro and micro dynamics may interact have been suggested (e.g., Giddens, 1984), researchers lack "adequate conceptual tools and techniques" for an examination of the paths of influence up and down levels of social phenomena (Barley, 1990).

The underlying logic of the argument presented here is that, for an adequate theoretical explication of organizational change processes, two prerequisites must be met. First, the issues of part/whole interrelationships must be addressed. However, the manner in which the part is related to the whole (and *vice versa*) directly affects the mechanisms through which structure affects action (and *vice versa*). Second, the issue of structure/action dialectics must be addressed. However, any attempt at linking objective structure and subjective action will eventually force a consideration of how macro and micro forces are linked. Explanations of structure/action and part/whole dialectics are not developed in isolation – the consideration of one dimension of social life must, of necessity, incorporate and confront the other. Only if these issues are accounted for can the issue of the mechanisms (e.g., the driver, director and source of change) and modalities of dynamic change processes be adequately explained. This premise is, further, congruent with the notion of the non-decomposability of complex adaptive systems as developed in Part II – because of the non-decomposable nature of social systems, dynamic theories of temporal processes require the inclusion of multiple levels of phenomena.

Hierarchical Structuring and Levels of Organizational Phenomena

The term "levels of analysis" was used earlier to distinguish between metatheoretical, theoretical, methodological and applied levels of analyzing phenomena. A second meaning commonly applied to "levels of analysis" refers to the levels of organizational phenomena under examination (i.e., part/whole). At least three levels of (internal) organizational phenomena are traditionally recognized and

> ...the level of analysis is determined by the nature of the dependent variable...whether the phenomena to be explained is (1) the behavior or attributes of individual participants within organizations, (2) the functioning or characteristics of some aspect or segment of organizational structure, or (3) the characteristics or actions of the organization viewed as a collective entity (Scott, 1992: 14).

To avoid semantic confusion, the phrase "*levels of analysis*" is reserved to indicate the first meaning. "*Levels of organizational phenomena*" is used when referring to the second meaning. An inclusion of levels of social phenomena – an account of its hierarchical structuring – is crucial in addressing the issues involved in explanations of organizational evolution, development and transformation

> ...not just because theories that cover intraorganization, organization, population, and community levels of organization are too numerous and diverse to fit into a single statement, but, more importantly, because organizational systems are themselves hierarchically arranged. As Simon (1962) has pointed out, hierarchical ordering is one of the most natural ways of organizing complexity (Baum and Singh, 1994: 8).

Hierarchical structuring as used here does not denote an ordering of power or authority relationships, in a Weberian sense, where human action is oriented to a hierarchy of functions in which there are commanders and commanded, leaders and followers (Clark, 1985) – as in the formal hierarchical structuring of organizational relationships. Neither does it suggest a simplistic ranking and subordination of levels of phenomena (as in the commonly used scheme of *individual—dyad—group—organizational—interorganizational—population—ecological* levels). These rather limited (though often used) conceptions of hierarchy suggest a model of organizational reality ordered around increasing levels of complexity where either (1) each level is merely an aggregation of elements from the "lower" level or (2) that processes at one level are isomorphic to the processes at another.

In the first case, the *doctrine of methodological individualism* is reductionism in its extreme form and makes an inferential leap between levels of phenomena to the presumption that individual (micro) level interactions can be statistically aggregated into the observed (macro) patterns of social activity. This presumption "...allows researchers to work at one level of analysis while blithely making inferences to another" (Barley, 1990: 66). In the second case, an *assumption of isomorphism* suggests a total separation of levels where phenomena are fundamentally distinct, clearly bounded and isolated from other levels as related to the causal mechanisms of dynamic processes. A link between levels is posited whenever attributes at one level correlate and appear consistent (because of the presumed isomorphism) with attributes at another. Both problems define away the problem of macro-micro linkages and neither offers an explicit conceptual framework for tracing the paths of influence between levels (Barley, 1990).

Reductionism and Theoretical Explanation. One implication of a reductionist position is that different levels and dimensions of change phenomena require different models and explanations of the dynamics for each level or dimension (Meyer, Brooks and Goes, 1990; Ven de Ven and Poole, 1995). This view, unfortunately, has contributed to the multitude of approaches and conceptual fragmentation in the organizational sciences. If the complexity perspective is to be taken seriously, researchers must concede that – not only are systems open to external factors – but that levels within the system are affected by, and affect, levels above and below. There is nothing in the recognition of progressive complexity that requires either a reductionist leap to simple aggregation or to a complete disassociation of phenomena at varying levels (Long *et al.*, 1999). The use of hierarchy in either manner may represent a danger or inhibition to scientific progress. Simon (1962) argued that because

> ...many systems have a nearly decomposable, hierarchic structure is a major facilitating factor enabling us to understand, to describe, and even to see such systems, and their parts. Or perhaps the proposition should be put the other way around. If there are important systems in the world that are complex without being hierarchic, they may to a considerable extent escape our observation and understanding (Simon, 1962: 477).

This partial decomposability facilitates analysis by allowing for the construction of *partial* theories designed to explain phenomena at a particular level. It might be, and often is, argued that much is learned about behavior of and in organizations by studying distinct analytical levels while ignoring the whole. Simon's argument is that what occurs at lower levels in the organization is largely ignored by "higher" levels unless some deviation occurs. According to this argument, the normal and recurring activities of a given individual, group, or department have little direct impact or affect on individuals in other parts of the organization, either at the same level or at levels above or below. Even so, Simon (1962: 481) contends that the "...path to a nontrivial theory of complex systems is by way of a theory of hierarchy."

Emergence and Theoretical Explanation. Because of the proposition that elements of one level are only *partially* (i.e., analytically) decomposable, not only do the parts not equal the whole but – because of the complex interactions among elements at differing levels – unique, non-additive results are obtained (i.e., *emerge*) at the next level (Grobstein, 1973). Though there is but little understanding about the decomposability of complex organizations (and under what conditions such decomposability might exist), the complexity sciences suggest that complex adaptive systems in general – because of nonlinearities, positive feedback and nonequilibrium – are inherently non-decomposable. This non-decomposability is a fundamental attribute of complex systems and is central to efforts at explanations of emergent phenomena where properties observed at a particular level are not apparent, isomorphic, or deducible from characteristics of adjacent levels.

Thus, analysts must not only construct models and theories that reflect an openness to external influences, but also reflect an openness to influences from levels above and below the focal level. The study of emergent phenomena seems to require such inclusion of levels issues because

> ...at a given level specific components appear with characteristic features; each level can be characterized by the dynamics of its own components and the system of constraints exerted upon this dynamics by the higher level...The inclusion of different organizational levels in models of social sciences cannot be avoided (Csányi, 1992: 23).

At this stage of theoretical development

> ...it is not known how the operation of the whole system is influenced by the regular and irregular changes on the various hierarchical levels. Which organizational levels must be manipulated, and how, if we want changes in certain directions and on given levels? <A major task for theorists is to identify>...the main functional connections and replicative pathways...taking into account the interdependence of different organizational levels (Csányi and Kampis, 1987: 246-248).

Thus, the "...processes *within* each level of each hierarchy...constitute only a small portion" of the dynamics of system change and transformation (Baum and Singh, 1994: 13). There are also important interactions *among* levels within each hierarchy in addition to interactions *between* entities at the same hierarchical level. While there is partial autonomy (i.e., partial decomposability) of events and processes within each hierarchical level, there also exists a degree of upward and downward causation. Though *analytically* decomposable, explanations of the temporal dynamics of complex systems cannot be developed without a consideration and inclusion of interactions at multiple levels of phenomena.

Holism: Heterarchies and Holons

Because of these factors (interactions *within* the focal level of a particular system, interactions *among* levels in that system, and interactions *between* systems), many prefer the use of *heterarchy* instead of hierarchy (Long, *et al.*, 1999; Baum and Singh, 1994; Hofstader, 1979). Heterarchies are hierarchical structures with multiple (positive and negative) feedback loops where processes and events at one level affect processes and events at other levels. It is generally assumed the dynamics of a particular level affect most strongly those of adjacent levels, both above and below the focal level (Baum and Singh, 1994; House *et al.*, 1995). Thus, any specified level of phenomena is subject to the *proximal* effects of adjacent levels, while levels further removed from the focal level exert *distal* effects. Levels of phenomena

> ...are loosely coupled, which means that some, but not all, events at any one system level will impact successively higher and lower system levels. The boundary between adjacent system levels constitutes a *two-way* interface or interchange (Arrow and McGrath, 1995).

The boundaries between levels of phenomena, as with the boundaries between system and environment, are conceptually, analytically and empirically separable from a hierarchical perspective. However, from a heterarchical perspective the levels of phenomena, though conceptually and analytically distinct, are empirically non-separable and non-decomposable – the totality of phenomena comprises a holistic entity.

While the focal level is indeed a constituent component of a larger system that it affects, and is affected by, it is itself a system composed of various subsystems. Koestler (1967, 1978) refers to such system components as *holons*, in preference to levels or subsystems, in order to reflect the dual and complementary aspect of these entities. Each "Janus-faced" holon

> ...has a dual tendency to preserve and assert its individuality as a quasi-autonomous whole; and to function as an integrated part of an existing or evolving larger whole. This polarity between the self-assertive and integrative tendencies is inherent in the concept of hierarchic order, and a universal characteristic of life. The self-assertive tendencies are the dynamic expression of holon wholeness, the integrative tendencies of its partness (Koestler, 1967: 343).[2]

The definitional boundaries of a holon and the identification of discrete levels within a hierarchical system are somewhat arbitrary and may depend on the particular purpose of any analysis (Allen and Starr, 1982).

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[2]Note that Koestler's reference to a "self-assertive tendency" and an "integrative tendency" echoes the discussion of system-wide needs for differentiation (self-assertion) and integration in Chapter 5. Self-assertion (differentiation) of system elements is necessary for the system to maintain the requisite variety needed for functioning in its environment. Integration is necessary for the system to maintain a degree of integrity and identity. These issues are also present in Lawrence and Lorsch (1967). The major difference is that Koestler argues for these as fundamental characteristics of the holon itself, rather than system-level characteristics or criteria.

Once the somewhat ephemeral nature of a holon's boundaries are recognized, however, it becomes apparent that it is *not the aggregation of lower level components* that lead to holons of higher levels – or to the system as a whole – but *the interactions within, among and between* the constituent holons. Though system levels may be analytically separable and partially decomposable, because of the multiple and bi-directional interactions and feedback between holons, it is impossible to understand any focal level without reference to levels above and below – each holon constitutes, and is constituted by, other holons. Thus, examination of phenomena operating at a particular level in a system must include phenomena operating at, at a minimum, contiguous levels (O'Neill, 1989; Koestler, 1967).

Though the more familiar *hierarchy* or hierarchical structuring continue to be used, the *caveats* noted here should be kept in mind. The concerns over the hierarchical structuring of social reality are most clearly apparent in the macro-micro problem in social theory.

Macro-Micro Issues in Organizational Studies

The fundamental problem of hierarchy in the social sciences is to explain the relationships between persons and collectivities: how individuals affect social structures and how those structures affect individuals over time. Commonly referred to as the problem of "macro-micro" linkages or the levels issue, the hierarchical structuring of social and organizational realities are often (even commonly) ignored by simplifying complex situations in an attempt to understand some small portion of social reality. Most often, the problem is conceptualized in one direction only – either from micro to macro or *vice versa*. Thus, the causal arrows in most social and behavioral models point, at least implicitly, in one direction because the interrelationships and reciprocal causality are too "messy" or the problem deemed too intractable (Huber, 1991). This macro-micro dichotomy led to Bennis' (1959) well-known characterization of perspectives on social organization as concerned with either "organizations without people" or "people without organization."

Some theorists view this situation as worrisome at best and, at worst, an impediment to the advancement of knowledge in the organizational sciences. This micro-macro dichotomy motivates a recent call for the development of a *meso* level paradigm that would specifically address micro and macro level phenomena simultaneously (House, Rousseau and Thomas-Hunt, 1995). *Meso* theory and research is multi-level in nature and combines at least two levels of analysis. At a minimum, this suggests that one or more elements of the research project include individual or group variables or processes and that one or more elements include organizational or environmental variables or processes. Further, it would offer some explanation of the processes through which the several levels are bridged or linked (Baum and Singh, 1994; House *et al.*, 1995; Long *et al.*, 1999).

Not all theorists, however, agree that the problem is quite so critical. Much effort has been expended in agonizing whether micro or macro levels are theoretically more important and in attempting to link one level of analysis to the other. Turner (1988) suggests that this effort may be premature, given the state of the art, and that

> ...rather than arguing for the primacy of one over the other or seeking to plug the gaps between them, perhaps we ought to ignore the issue, at least for the time being. Let us instead develop precise micro theories of interaction, on the one side, and macro theories of social structure, on the other. Only them will we be able to determine what points, if any at all, of theoretical reconciliation between these levels are evident (Turner, 1988: viii).

Further, Turner (1988) suggests that micro and macro analysis will always remain theoretically disconnected and that research that mixes macro and micro level concepts (as in the meso level paradigm above) has confused matters to such an extent that *neither* the micro or macro levels are adequately conceptualized. Each is important to understanding social behaviors, but neither is more important – they simply provide different insights into social activities and offer alternative "theoretical lenses" for the analysis of similar issues.

However, Turner does note that both micro- and macro-level phenomena are required for adequate explanations of social processes. Micro-level interactions construct and maintain macro-level structures – there would be no macro-structures without individuals. On the other hand, "...macro-social structures serve to constrain micro interactions by limiting the symbolic and material resources available to individuals, the placement of people in time and space, the amount of time people have and the options that are realistically available" (Turner, 1988: 211).[3]

Though his analysis is decidedly micro in focus, Turner suggests that more can be learned about social interaction processes by examining macrostructural constraints than can ever be learned by an exclusive focus on micro-level interactions. It is more intuitive (in Turner's view) to suggest how macro-level processes constrain micro-phenomena; it is much more difficult to conceptualize how the myriad of micro-interactions can be aggregated to explain macro-level phenomena. Despite this difficulty, researchers and theorists

> ...cannot continue to conceptualize in a vague manner that the macro is composed of aggregated micro encounters, as so many micro theorists have done. Such assertions are not only vague, but they also ignore *the issue of emergent properties* (Turner, 1988: 211; emphasis added).

Defining Social Organization

The macro-micro dichotomy of "traditional" science is clearly reflected in definitions of social organization and conceptualizations of core organizational features. The movement from a cybernetic systems (Stage One) view of organizations as collectivities controlled by negative feedback mechanisms to

[3] The most prominent effort to deal with the issue of macro-micro linkages is Giddens' (1984) structuration theory. Though often cited, structuration theory has been criticized as having little point of contact with the empirical world – it has proven difficult to operationalize conceptualizations derived from structuration theory.

an open systems (Stage Two) view of interchange and interaction with the environment has not diminished the macro-micro gap. To the contrary, an open systems perspective has the effect of broadening the part/whole dichotomy by increasing the scope of concerns to include the issue of external (i.e., environmental) control of organizational activities. For example, most contemporary theories of organizational level change posit a "...model of environmentally driven change whereby external changes produce organizational changes" (Carroll, 1993: 239).

Even theoretical approaches that posit an internal source of change (e.g., Alchian, 1950; Child, 1972; Nelson and Winter, 1982) tend to couch explanations of change at the organizational (or system) level. These explanations stress the importance of rational actions of managers and organizational decision-makers who plan system-wide change and manipulate organizational level variables in a conscious effort to increase organizational effectiveness and efficiencies.

Even when individual members of the organization are considered in explanations of organizational change processes they are generally regarded as impediments to change processes. Individual members of the organization are seen as inhibitors of change either because of the forces of *social inertia* (Dale and Davies, 1994; Laughlin, 1991) or because of the *unintended consequences* of rationally designed change programs (March, 1978, 1981). Efforts at internal system change (whether reactive or proactive), though intentionally and rationally planned, are complicated by member resistance to change or by the unintended and undirected consequences of those intentional acts. In most explanations of organizational change, the acts and actions of individual members are effectively divorced from explanatory mechanisms.

This lack of inclusion of micro-level (individual) factors in explanations of organizational change processes is evidenced by the variables chosen for inclusion in most theories of organizational change processes, regardless of their theoretical and paradigmatic foundations. Hannan and Freeman (1984) suggest that the "core" organizational features are the *stated goals*, *forms of authority*, *core technology* and *marketing strategy* of the organizational system. Because investments in these core features create inertial effects – largely because of the risks associated with change and requirements of reliability and accountability – organizations are relatively inert (i.e., slow to change) as compared to rates of environmental change. In a similar manner, Tushman and Romanelli's (1985) theory of punctuated equilibrium posits five crucial contingencies in organizational change processes: *culture* (core beliefs about the organization, its members, and environment); *strategy* (products, markets, technology, and competitive timing); *structure*; *power distributions*; and *control systems*.

In an analysis of environmental disturbances and organizational transformations, Laughlin (1991) forwards this definition of core organizational features:

> Organizations...will be conceptualized as being an amalgam of 'interpretive schemes', 'design archetypes' and 'sub-systems' (ranging from intangible to tangible components, respectively) (Laughlin, 1991: 211).

Laughlin's conceptualization of "design archetypes" is similar to Gersick's (1991) view of "deep structure" as

> ...a network of fundamental, interdependent "choices" of the basic configuration into which a system's units are organized, and the activities that maintain both this configuration and the system's resource exchange with the environment (Gersick, 1991: 15).

Individuals may employ "interpretive schemes" in order to make the "fundamental, interdependent choices" but the mechanisms through which these affect, and are affected by, the resulting structural arrangements is not explicitly considered in either approach.

Some change models do include an "individual" component into their explanatory framework. For example Nadler (1983), building on the transformation processes of open systems, suggests that the four major internal components are the specific *task* facing the organization, the *individuals* who are members of the system, the *formal organizational arrangements*, and *informal organizational arrangements*. However, Nadler's perspective is definitely a systems level approach with only a cursory examination of individual level phenomena (again, individual action is "averaged out"). Similarly, Mintzberg and Westley (1992) discuss four levels of change phenomena (*culture*, *structure*, *systems* and *people*) in their analysis of cycles of organizational change. They suggest that change phenomena occur at each level, but do not offer a detailed specification of how change at one level is related to, or dependent on, change at another level.[4]

The point being made is that, while individuals are *implicitly* included in conceptualization of organizational "core features" or core elements, individual acts and actions are not usually *explicitly* considered. For example, the existence of individuals is certainly implied by the notions of structure, authority relationships, power distributions, and sub-systems in these typologies. However, the effects of *individual* actions and activities are not considered significant factors in explanations of organizational level change processes (i.e., the effects of individual members are either "averaged out" through aggregation or assumed away through a presumption of isomorphism).

Even perspectives founded on arguments that changes in tasks and skills at the individual level create opportunities and pressures for change at the organizational level have altered their focus. For example, though sociotechnical systems theory (Trist and Bamforth, 1951; Rice, 1958) was initially founded on the premise of examining the relationship between microsocial processes and social structure, by the 1970s it had abandoned its focus on the microsocial dynamics of change (Barley, 1990).

Thus, the influence of individuals on the processes and progression of organizational change (whether through natural ecological and evolutionary processes or through rational adaptation to environmental contingencies) has

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[4]Obviously, these few examples are meant to be representative, not exhaustive.

been widely neglected and theoretical approaches to system dynamics still emphasize Bennis' "organization without people."[5] The failure to provide an adequate theoretical explanation of organizational developmental and transformational processes has occurred, in large part, because of the failure to provide an adequate explanation of the mechanisms through which acts and actions at the individual level affect, and are affected by, system level phenomena. Thus, within the broader context of the debates over organizational change, evolution, transformation and adaptation, the effects of individuals are largely ignored.

The promise of the complexity sciences is that they provide a new theoretical lens through which these mechanisms can be explored. This lens offers a perspective – by focusing on interactions among system elements – for framing and investigating the mechanisms through which part/whole *and* action/structure dialectics occur.

The Complexity Science Perspective

The CAS approach focuses on understanding the collective self-organizing behavior of many basic but interacting units and on formulating

[5]This is not to suggest that micro issues have been totally ignored. For example, Weick's (1979) E-S-R (enactment—selection—retention) model and his conceptualization of organizations as "loosely-coupled systems" focus primarily on micro dynamics. Barley's (1990) examination of technological change and its impact on structural arrangements (through the mechanisms of role relationships and social networks) is the most notable recent effort to link macro and micro phenomena.

explanations of how such collectivities evolve, change and develop over time (Coveney and Highfield, 1995). Thus, central to CAS is an exploration of the processes by and through which micro level interactions lead to emergent (i.e., macro level) properties in complex systems. To this point, quantitative explorations of the dynamics of nonlinear systems (i.e., chaos and catastrophe theories) have had little impact in the social sciences (Horgan, 1995). Both chaos and catastrophe approaches to complexity, though suggestive, focus on systems defined by fixed equations (rules or laws) as occurring in many physical and biological systems. Through manipulation of these equations many provocative implications have been derived: non-linear behavior in the form of stable and unstable zones (bounded instability); apparent indeterminacy in the form of random and/or chaotic (but with an underlying fractal pattern); sensitivity to initial conditions; bifurcations and catastrophes; and, far-from-equilibrium behaviors.

However, the problem with applying a deterministic framework to social and organizational systems is that there may be few fixed laws or rules that determine the behavior of a social system (Wilkinson, 1990; Wollins, 1996; Stacey, 1996b).[6] In other words, the cognitive and intentionally generated behaviors of human actors have been difficult to integrate into such

[6]Of course, the argument could be made that such fixed laws do exist but they have not been discovered yet. That may be true, but does not negate the point that (for this reason) chaos and catastrophe theories have had little impact in the social sciences beyond metaphor and analogy. Further, even if such laws exist (and if the arguments of Chapter 6 are granted), these behaviors – even though governed by fixed and immutable nomothetic structures – have the appearance of resulting from the free-will and independent choices of individuals.

perspectives. Rules governing interactions – the system's GTYPE – between actors or organizations can, and may, change periodically (perhaps, at will). Thus, Bygrave's (1989b) claim that there has been little empirical support for the existence of deterministic chaos in social systems is not surprising. However, as argued in Chapter 5, the insights provided by these early approaches to explanations of complex system behaviors have been extended through the incorporation of elements of self-organized criticality, self-organization, and dissipative structures to form a more general approach founded on Stage Three assumptions – *complex adaptive systems* (CAS).

CAS consist of a large number of interdependent elements (actors or individuals) that interact, not only among themselves, but also with other elements and systems in the external environment. Instead of being bound by fixed rules of interaction, actors adapt behaviors by modifying rules of interaction (i.e., schema)[7] through experience and learning. CAS are non-linear systems and the effects of interactions flow through the system in both positive and negative feedback loops. Negative feedback tends to stabilize system dynamics – it tends to promote stability while inhibiting change. Positive feedback amplifies small disturbances in ways that can be either beneficial or detrimental (i.e., virtuous or vicious circles) to system functions – it tends to move the system toward innovation and change, but also moves the system

[7]A more specific definition of the "schema" construct will be provided shortly.

toward instability and far-from-equilibrium states. The effects of positive feedback are, however, constrained by the availability of system resources and by offsetting negative feedback loops.

CAS are self-organizing in that order emerges at the (macro) system level from the interaction of the system's many (micro) elements or actors, rather than being externally imposed. CAS may exhibit stability, bounded instability or even self-destructive instability (chaos) depending on the particular values of the control parameters[8] governing system dynamics. However, it is in that complex region between stability/inertia and instability/chaos where change, transformation and adaptation occur. Because complex system behaviors are hypothesized to emerge from and depend on recurring interactions among system elements, researchers should focus on the examination of such interactions. This implies that to explain social system dynamics – to offer an explanation of how social systems move from one region to another – one should focus on a close examination of the interactions between individual members of the social organization.

A Focus on Interacting Elements

CAS are hypothesized to function through an analysis of information in order to extract regularities, building them into schema that are continually

[8]These control parameters were discussed in Chapter Five and will be considered in more detail with respect to the analytical model of organizational dynamics developed later in the present chapter.

changed (or adapted) in the light of experience (Stacey, 1996b). CAS reorder themselves internally by rearranging the connections and/or altering the logic or rules governing connections and interaction sequences between elements. Additionally, CAS possess the ability to maintain coherence in spite of constant internal and external change. Moreover, CAS are open to environmental influences and environmental factors contribute to subsequent systems behaviors. The system depends on exchange and interchange with its environment (for energy and resources) and adjusts internal relations based on anticipated or learned consequences of its acts and actions (Holland, 1995). In this sense, complex adaptive systems are self-organizing, nonequilibrium dissipative structures.

Social systems would appear to fit the criteria established for CAS. In order to clarify and extend this argument, several assumptions are posited. These assumptions are not particularly controversial, but are forwarded in order to make the foundations of subsequent arguments explicit.[9]

Assumption 7.1: The basic elements of a social system are individuals.

Assumption 7.2: The fundamental mechanism through which the dynamics of social systems occur is the interaction and exchange between individual members.

Assumption 7.3: Interactions within social systems are open to external (i.e., environmental) influences. That is, social systems fall into the class of open systems.

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[9]The assumptions, definitions and propositions developed in this chapter are listed in Table 7.1 of Appendix C.

Assumption 7.4: Structural arrangements in social systems derive from the spatial and temporal patterns of interaction and exchange that connect individual members of the system.

These assumptions suggest the following definition:

Definition 7.1: A social system is a relatively dense collection of dyadic interactions where individuals are connected to each other according to some logic, set of rules or laws. This logic defines and delimits the appropriate means, modes and methods of interaction and exchange in the dyadic relationship.

Thus, social systems can be characterized as macro-level structures that emerge from recurring micro-level interactions and exchanges among constituent elements.[10] Such interactions are jointly conditioned by the interplay between objective criteria and the subjective, cognitive understanding of those criteria *and* the interplay between individual level and system level phenomena. The connections (interactions and exchanges) between elements constitute the objective structural arrangements of the system, but each individual connection is governed by its own set of rules, laws and logic. In the case of social systems, the rules, laws and logic guiding interactions are conditioned by the cognitive and subjective interpretations of individuals. An individual's subjective understanding and interpretation of the "rules" and the learned and anticipated consequences of interactions with others provides the foundation for intentional behaviors at the dyadic level.

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[10]More formally, the discussion should be framed with reference to the interplay between *holons* at various levels of the social system. However, in the interest of clarity, the discussion will refer to individual and system levels of phenomena while recognizing that the interactions are more complex than the simple individual/system dichotomy suggests.

To paraphrase March and Simon (1958) the basic features of organizational structure derive from the networks of interactions between and among organizational members. Varying combinations of elements and interactions (i.e., individuals and linkages) define the structure of the organization. Moreover, these combinations are "open" to environmental influence; that is, individuals interact not only with their physical surroundings and other individuals within the organization but also with other elements (individuals and organizations) in the external environment. These interactions occur during all phases in the processes of transforming inputs into outputs. This perspective suggests a necessity to focus more closely on the interactions and exchanges that define the connections among individual members of the system. Thus, a fundamental proposition is that:

Proposition 7.1: Because (1) the basic elements of social systems are individuals and (2) the dynamics and structuring of social system behaviors result primarily from the interactions and exchanges among those members, the fundamental unit of analysis is the connection between individuals.

This assertion may seem to imply a reductionist position. However, to argue that dyadic connections are the elementary building blocks of social organization does not mean that all social phenomena can be explained solely with reference to – i.e., reduced to – connections at the dyadic level. It is, though, a fundamental proposition that macro-level social phenomena emerge from the temporal and spatial dynamics of such recurring interaction and exchange sequences that define the connections among individual members of the system.

Turner's (1988) theoretical synthesis of the dynamics of dyadic social interaction provides the necessary micro-foundations to extend and further specify the line of argument suggested by Proposition 7.1 and provides a point of intersection between the social sciences and the complexity sciences. Though decidedly micro in focus, when enhanced by developments in the complexity sciences Turner's dynamic theory of dyadic social interactional processes nevertheless suggests an approach to understanding the complex interrelationships of macro- and micro-level theories, variables and concepts that continue to confound organizational researchers. The challenge is to offer an explanation of the general principles which link a myriad of recurring micro-level interactions to macro-level phenomena and the processes through which intentional behavior (conditioned by subjective and cognitive understanding) is linked to objective, observable structural arrangements.

The Structuring Dynamics of Dyadic Social Interactions

Turner's (1988) purpose is to develop a dynamic model of the processes of social interaction. Social interaction is defined as "...a situation where the behaviors of one actor are consciously reorganized by, and influence the behavior of, another actor" (Turner, 1988: 14). Overt individual behaviors and covert cognitive processes are the domain of psychology – it is when these individual behaviors and processes come into contact with others that provides the basis for "social" activity. Thus, social activity results from the complex relationships between (1) the overt actions of individuals in time and space, (2) the covert (or cognitive) deliberations of individuals, and (3) the underlying physiological processes of individuals.

Social interaction is composed of three analytically distinct processes: motivational processes, interactional processes, and structuring processes (Turner, 1988: 15; Figure 7.1). "*Motivational processes*" are those which explain how (to varying degrees and in diverse ways) individuals are energized and mobilized to engage in interactions with others – what provides the impetus for an interaction episode. "*Interactional processes*" denote what people actually do when they influence each other's behavior – what actually occurs during the interaction. "*Structuring processes*" are concerned with how social interactions are repeated across time and organized in physical space – what explains the spatial and temporal consistency, or lack thereof, of interactional sequences. Separate (and distinct) models and principles can be developed to explain the mechanisms of each process. However neither can the processes, considered separately, adequately explain the dynamics of dyadic interaction nor can any one be conceptualized solely in terms of the other. Each is analytically distinct and separable, but only in combination do they offer an explanation of the operative dynamics of dyadic interaction.

The manner in which people signal and interpret (interactional processes) is closely related to the motivational energies of the individuals involved in the interaction. In turn, motivation is circumscribed by prevailing structural arrangements as well as by the actual mechanisms of the signaling and interpreting activities. Finally, the structure of an interaction is affected by the motivations of the individuals involved as affected by the signaling and interpreting activities. The point of decomposing the interaction process into its constituent processes (and developing separate models and propositions for each) is to examine the causal influences of each process on the others.

A more complete discussion[11] of Turner's analysis is developed in Appendix A. The primary implication drawn here is that the fundamental unit of analysis (sociologically) is the dyadic interaction. Dyadic social interactions provide a conceptual link (Tolbert's "point of intersection") with the connectionist perspective on complex adaptive systems developed in Chapter 5. As individuals mobilize motivational energies and engage in dyadic interactions (i.e., connections are established with others) over time, the property of most interest here emerges: social structure. This emergent property (social structure) is

> ...not a "thing," however, but a process in which individuals produce and reproduce patterned sequences of interactive responses. And once created, these established sequences become, in a sense, a "mental

[11]An explanation of Turner's approach is considered significant, in that it provides the micro foundations for the connectionist model organizational dynamics under development. However, it is not deemed so crucial as to require the explanation within the body of the analysis.

> template" or "schema" for how those individuals will interact when they resume contact. When such cognitive schemes can be learned by others, then successive sets of actors can enter into situations and repeat the lines of behavior created by others, often in the distant past. Thus, the process of structuring is, on the one hand, an overt patterning of behaviors in time and space and, on the other hand, a mental modeling of information about what interactive sequences apply to varying types of situations (Turner, 1988: 149).

Thus, the objective attributes of social structure cannot be separated from the subjective process of structuring. Neither can the objective patterning of relationships be separated from the subjectively based, cognitive schema governing those interactions.

Though an eminently "social" perspective, a view of structure as emerging out of a myriad of socially constructed and negotiated interactions among individuals provides little insight and few analytical tools for explicating the links between the micro-level interaction order, macro-level formal organizational structures, and the dynamics of social change processes. However, when enhanced and extended with implications derived from the connectionist perspective of CAS, the integrative model of organizational dynamics provides such insight.

A Connectionist Theory of Organizational Dynamics

The theoretical approach to social interaction described above provides the social and behavioral foundations for the development of a connectionist theory of organizational dynamics.[12] The proposed analytical model addresses two primary areas of concern: the spatial characteristics of the system and an explanation of the temporal dynamics of the system. In the first case, consideration of the spatial characteristic entails

1) defining the system,
2) defining the elements that constitute the connections among elements of the system,
3) integrating a cognitive element (i.e., intentionality) into the framework, and
4) explicating the interplay between control parameters and mechanisms that drive and direct system behaviors.

The second issue concerns providing an explanation of how these spatial elements change (i.e., develop and transform) over time. That is, the model should describe the temporal dynamics of the system and explain how the process, context and history of micro-level interactions are linked to macro-level phenomena such as changes in organizational structure.

A Connectionist Definition of Social Organization

A view of dyadic interactions as the fundamental unit of social analysis has a rich tradition in the social sciences. It provides the foundation for much of

[12] It may be noted that not a great degree of specificity has been attached to the terms "organization" and "organizational." This is intentional – from the connectionist perspective, a social system (i.e., an organization) is defined by the connections which link individuals, not by the ends for which the system was established (see Definition 7.1). The proposed model is intended to be general enough to allow for application in various organizational and social settings – from restrictive and directive social organizations such as prisons, to for-profit enterprises, to not-for-profit organizations, to more voluntary social settings such as clubs and associations. The differentiating factor is the type of connection in terms of type of interaction and the flows through those connections. This is clarified and discussed in detail later in this chapter.

the interactionist and exchange-theoretic approaches, as it does for social network analysis.[13] Social network analysis, in particular, emphasizes the configuration and content of contacts (i.e., "ties" or linkages) between sets of actors with the intent of examining how these ties affect organizational performance (e.g., Pearce and David, 1983). Most studies using network techniques have focused on either the spatial configuration of interaction networks or on the effects of varying degrees of tie strength on individual and group level phenomena (e.g., job turnover, influence, levels of communication and group performance). Despite its promise and the fact that important insights have derived from the network analytic approach, social network analysis has not proven particularly useful in explanations of organizational dynamics. In large part, this is a result of a reliance on traditional categorization and correlation methods. More pertinent is that social network techniques tend to focus *either* on individual characteristics (as in structural and configurational approaches) *or* on the exchanges between the individuals (interactional approaches that focus on the type of ties between individuals).[14]

With respect to the problem of macro-micro linkages in the social sciences, however, the network approach offers the potential for a resolution of the part/whole dichotomy. Neither a holistic perspective that attempts to view

[13]See Turner (1988) among many others for arguments to support this contention.

[14]See Nelson and Mathews (1991b) for more on this subject.

social systems in their totality nor a reductionist emphasis on individual acts and actions

> ...is a sound starting point for analysis. Put simply, the problem is that neither perspective pays adequate attention to the *constructed* nature of both individuals and groups. A good opening to this has come in the growing influence of the network approach, which has followed earlier social anthropologists in suggesting that the proper unit of analysis is neither individuals nor whole societies but the structure of social relationships (Nadel, 1957). There is no reason, though, that the study of relationships should emphasize structure to the exclusion of action. In Giddens' (1985) terminology, we could say that the historical process of structuration is emphatically *not* a mediation between individual and society, for both individual and society are its products, or its contents, not its starting points. What is primary is the intersubjective process (Calhoun, 1991: 59).

Structural arrangements in formal organizational systems cannot be adequately characterized with sole reference to either formally prescribed interaction patterns or to informally emerging patterns of interaction. Moreover both a subjective and socially constructed interaction order as well as objective (i.e., "real") attributes affect the dynamics of structural change. This contention suggests the following proposition:

Proposition 7.2: Organizational structure results from (1) formal macro-level configurations (prescribed interactions), (2) informal micro-level configurations (interaction order), and (3) the interplay between the objective attributes of that structure and the socially constructed, subjective interpretations of those attributes.

This proposition suggests that the fundamental and essential feature of social and organizational systems are the connections between individual elements that form its *deep structure* (Gersick, 1991).[15] An organization's deep structure results from the interactions between formal macro- and informal micro-level phenomena and between the subjective and objective dimensions of social action. Deep structure is what "...persists and limits change during equilibrium periods, and it is what disassembles, reconfigures, and enforces wholesale change during revolutionary punctuations" (Gersick, 1991: 12). However, the construct is not (1) a particular configuration of *forms* of interaction, (2) a system of *exchanges* between individual members of the organization or (3) a vague and general system of "fundamental interdependent choices of configurations." Rather, deep structure is conceptualized as (1) the global pattern or configuration of multidimensional connections among all members of the organization that (2) emerges from the ongoing and recurring formal and informal relationships among all members as (3) conditioned by the intersection of macro forces, micro forces, subjective interpretation and objective attributes.

Definition 7.2: *Deep structure* is that specific configuration or pattern of connections – interactions and exchanges – that links all members of the organizational system at any particular point in time.

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[15]Though clearly derived from the arguments forwarded by Gersick, the meaning of *deep structure* (as will be developed) is more specific than a "...network of fundamental, interdependent "choices" of the basic configuration" of the system. The argument presented here is that those "choices" are manifested in the connections between the elementary units of the system.

Any change or modification of social structure is, by definition, grounded in changes that occur at the level of dyadic connection.

The deep structure of connections provides both (1) the "paths" through which inputs and outputs (energy, information and resources) flow through the organization and (2) the "means" and modalities through which internal elements (i.e., individuals, groups and subsystems) interact with each other in order to accomplish individual and collective goals and objectives. The connections that constitute the organization's deep structure are, thus, composed of two factors: the flows of exchange through those interactional networks and the modes of interaction among actors (interaction networks).

Definition 7.3: Connections are conceptualized as composed of two elements: modes of interaction and flows of exchanges.

Deep structure is, thus, a multidimensional construct consisting of modes of interaction between individual members of the organization *and* flows of exchange through the connection. It is through this deep structure – the particular pattern and configuration of connections – that organizational activities are carried out and through which inputs are transformed and converted into outputs. Each component of the connection (interaction mode and flow of exchange) is, in itself, multidimensional. The constituent elements of this conceptualization and their relationship to the system's deep structure are illustrated in Figure 7.2 and discussed below.

A Typology of Modes of Interaction

Individuals relate differently to one another according to the context of the interaction situation and make an initial categorization of each interaction sequence based on future expectations and past experience (Turner, 1988). This categorization, if consensually agreed upon, facilitates the intersubjective understanding of the appropriate behaviors and responses without the need for a fine-tuning of signaling and interpretation. Without such categorization, the structuring of interaction would be difficult – each situation would have to be viewed as unique and require considerable effort at establishing the rules and guidelines for exchange relationships. Thus, actors simplify interaction situations by categorizing them in a few general classes.

Interactions between members within social systems are posited to take place through one of three modes of interaction: the formal/prescribed mode, the informal/social mode, and the symbolic/ceremonial mode. Each mode provides a differing contextual setting for any particular or specific interaction sequence. Each category, or mode of interaction, simplifies the organization of individual responses in the interaction sequence because each individual "knows" the range and type of behaviors appropriate to the situation.

Formal/Prescribed. The formal or prescribe interaction mode refers to the dimension of the connection between members conditioned by organizationally sanctioned and prescribed rules of interaction.

Definition 7.4: The formal or prescribed mode of interaction is that mode of interacting that reflects the organizationally defined and designated aspects of any interaction episode.

The context for such interactions can be described by characteristics that define "proper" interactions among organizational members with respect to formally designated and defined relationships. The formal or prescribed mode of interaction is, thus, closely related to organizational attributes such as authority and reporting relationships, the degree of centralization and formalization, chains of command and communication flows, levels of formal hierarchy, etc. that define the formal structure of the organization. This mode affects the differential distributions of power in exchange relationships, the degree of autonomy and freedom of action available to each individual, and provides an approved framework for the "official" flows through the organization.

Informal/Social. The informal or social mode of interaction refers to that dimension of interaction among members of an organization that has a personal, rather than formal, component.

Definition 7.5: The informal or social mode of interaction is that mode of interacting that arises through the day-to-day interactions among actors in the organizational system.

Strongly influenced by its affective content (i.e., friendship and liking), this mode can either support, inhibit or circumvent formal and prescribed modes. The informal or social mode is conditioned by the frequency of contacts between the individuals, the level of reciprocity in the interaction, the emotional intensity of the interaction, and the degree of intimacy between the actors (Granovetter, 1973; Nelson and Mathews, 1991b; Mathews *et al.*, 1998).

Ceremonial/Symbolic. The ceremonial or symbolic mode of interaction between organizational members taps the cultural and normative elements inherent in relations between two individuals.

Definition 7.6: The ceremonial or symbolic mode of interaction is that mode of interacting that reflects the cultural and deferential aspects of interaction episodes.

As such, it reflects the system of shared values and beliefs that interact with the organization's people, structure, and systems to produce behavioral norms that serve to condition the connection. These interacting and interdependent sets of beliefs, values and ways of behaving are so common and pervasive that they tend to perpetuate themselves. This continuity is the product of a variety of social forces that are frequently subtle and taken for granted. However, such norms and values, though rarely explicitly acknowledged, provide socially approved means of interaction and appropriated levels of deference to others. The cultural and symbolic dimension of the connection indicates, implicitly, how individuals are rewarded when the norms and values are accepted and how they are "penalized" (i.e., ostracized) when they are disregarded (see, for example, Hofstede, 1984, 1991; Wilhelm, 1992). This dimension is a critical conditioning element of the connection.

These three elements constitute the various modalities of interaction among organizational members and, by extension, between the system and the external environment. The composite combinations serve to define relationships between actors and their tangible surroundings (other actors, groups, technology, machines, etc). Thus the fundamental components of the organization consist not only of the tangible or physical (individuals) elements, but also intangible or cognitive elements which have no physical existence (i.e., the mode of interaction). These modes of interaction may have no physical reality but do have a social and economic reality that serve either to modify the relationships between physical elements (i.e., individuals) or to act as primary elements in and of themselves. It is emphasized that though the three modes of interaction are conceptually distinct any particular interaction has elements of each mode embedded within it. Thus, though analytically and conceptually distinct, the actual mode of interaction is not empirically decomposable. In any particular interaction sequence, however, one of the modes is presumed to predominate and provide the predominant context for subsequent behaviors in, and exchanges through, the connection.

A Typology of Exchange Flows

Flows refer to the exchanges of material and symbolic resources that move through the organization along the three interactional networks, or three modes, described above.

Definition 7.7: Flows in an organization refer to *what* is exchanged in any interactional sequence (i.e., the content of the exchange).

Flows are conceptually distinct from modes of interaction. Modes of interaction provide a shorthand categorization of the situation for individuals that serve to indicate an appropriate range and type of behaviors in the interaction episode (i.e., "how" the interaction sequence should proceed), while flows represents "what" types of resources are exchanged in the interaction. While the particular mode of interaction defines the behaviors and responses expected of each party to the interaction, the flows of exchange refer to the actual content of the exchange interaction. Four types of resources can be conceptualized as flowing through interaction networks in social organizations.

Definition 7.8: Flows of exchanges are either:
1) instrumental or technical flows;
2) power or authority flows;
3) communication and information flows;
4) affect or friendship flows.

Exchanges between individuals are, as with the modes of interaction, multidimensional. The four primary dimensions of exchange elements are *instrumental and technical* flows, *power and authority* flows, *communication and information* flows, and *affect or friendship* flows. *Instrumental and technical* flows consist of the movement and exchange of physical and tangible resources along the connecting paths. These flows are generally, but not necessarily, conditioned by the nature of the tasks and products (i.e., the conversion or transformation process) and largely determined by the formal structural arrangements of the organization. *Power and authority* flows, likewise, reflect organizationally sanctioned and defined formal dependency relationships (i.e., the chain of command) between individual members. However, power and authority flows are not entirely dependent on formally prescribed modes of interaction; there is a substantial informal and cultural component to these types of flows (especially with regard to power and dependency relationships). *Communication and information* flows, likewise, have both a formal and an informal/cultural component. Information flows along prescribed and defined formal channels, but also through informal channels (i.e., the grapevine). *Affect and friendship* flows refer to the emotional and psychological elements exchanged in the interaction. These flows are largely conditioned by informal, social and cultural factors.

As with modes of interaction, flows are conceptually and analytically distinct but empirically intertwined. For example, in any exchange of material and physical resources in an organizational setting, there is an element of communication and information exchange. Likewise, such instrumental exchanges are likely to be colored by affect and power/authority considerations. The point suggested here is that any particular connection between individuals in an organization is a composite of all four of the exchange dimensions. The controlling dimension depends in large measure on the particular circumstances (i.e., the purpose and context) surrounding the interaction, but all four components all present at all times. The deep structure of connections is defined – not only by the modal network of relationships – but also by what is exchanged in those networks. Thus, a connection is a multidimensional construct consisting of modes of interaction and exchange flows. In turn, interaction modes and flows of exchange are multidimensional constructs.

Linking Interaction Type to Flow Type: Connections

These multidimensional connections (three modes and four flows) are the fundamental units or building blocks of the organization's deep structure. A focus on the connections between organizational members provides a link to insights from the complexity sciences, particularly with regard to CAS, and the offers the potential for integrating those insights into the organizational and social sciences primarily with respect to interactionist and exchange approaches. Alternatively, social interaction and exchange processes provide the foundation for a connectionist view of human social structuring and the conceptual link to CAS. This connectionist approach overcomes limitations inherent in either a strict interactionist or exchange approach. Interactionist perspectives are limited by a primary focus on the individual and his/her efforts to initiate and gain from the interaction. Exchange approaches are limited by a focus on the content of flows through those interaction networks. A connectionist perspective reorients the focus to the linkages themselves by posting a multidimensional construct linking the *mode of interaction* to *exchange flow* during that interaction.

The connection between any two actors is a combination of each of these features – though conceptually and analytically decomposable, they are empirically inseparable.[16] Though beyond the scope of the current effort, it appears intuitive to suggest traditional behavioral topics such as role conflict, uncertainty and ambiguity could easily be integrated into the framework. For example, role uncertainty occurs when there is a question as to which element of the connection (i.e., which mode is primary and what is to be exchanged) is most relevant, given the context and history of the exchange interaction. Likewise, depending on the "purpose" of the organization (e.g., coercive, utilitarian or normative – see Etzioni, 1961, 1964), different configurations of connections will be emphasized or more common. For example, the deep structure of a coercive organization (e.g., a prison or the military) would tend to have a higher degree of formal/prescribed modes of interaction and more emphasis on formal power/authority and instrumental/technical exchanges. The deep structure of a normative organization (e.g., churches, social groups), on the other hand, would consist primarily of ceremonial/symbolic and informal/social modes of interaction and emphasize the

[16]Consider, for example, the case of an employer and employee. In their interactions, there is a primary reliance on the formal/prescribed mode of interacting especially with regard to instrumental/technical and authority/power relations. However, there is an affective/social component (whether the employee "likes" or "dislikes" the boss and *vice versa*) that moderates the formal aspects of the relationship. Similarly, there is a cultural/symbolic aspect to the relationship conditioned by norms regarding the degree of deference and respect due to, and from, superior to subordinate. In any specific interaction episode, one of these modes may predominate but, to some degree, all are present in each sequence. The mode of interacting is, additionally, conditioned by the flow of materials and resources (power/authority, instrumental/technical, communication/information or affect/friendship) exchanged in the interaction. The connection between the employer and employee is jointly determined by the confluence of these flows and modes. Roles uncertainty, ambiguity and conflict may result when there is misunderstanding or confusion over which element of the connection is primary.

informational/communication and affect/friendship elements of exchanges between individual members.

Connections and Holons. The deep structure of an organization is constituted by those connections and, in turn, the existing structure of connections serves to constrain and define appropriate modes of interaction and exchange flows between members. Implicit in this argument is a view of social organization as a series of holons linking interactions at the individual level (dyadic connections) to macro level phenomena. Though not explicit in the argument, it should be noted that various levels of holons could be identified (i.e., groups and sub-systems of the organization) between the individual and system. At each level, the holon is identified and defined by its specific configuration of connections. Likewise, the argument implies a view of the external environment as composed of similar types of connections linking holons at levels above the focal system. The external environment is, thus, a system of connections of these higher level holons – the deep structure of the "environment" is constituted by these interactions and exchanges (i.e., connections) between elements of the environmental holon.

Connections and System Behaviors. Though the connectionist perspective suggests a method of linking macro- and micro-level phenomena (through the constituent connections), it does not provide an explanation of the process though which this occurs. To develop an explanation of the process through which this linkage occurs requires that two additional elements be introduced into the model: (1) the interplay between control mechanisms and control parameters and (2) the "intentionality" of actors (the cognitive component of the model).

Control parameters are those critical system attributes or characteristics that determine its temporal dynamics – whether the system is inert, stable, complex or chaotic. Chapter 5 identified five such critical parameters for complex adaptive systems (rate of flows through the system, the density of connections within the system, the strength of connections between system elements, differential degrees of influence among individual elements, and the degree of diversity of system elements). Thus, the specific values of the control parameters result from the particular configuration of connections in the organizational deep structure. That is, the configuration of connections provides the system's GTYPE the lead to various values of the five control parameters. The values attached to those parameters lead to the system's observed behaviors or its PTYPE.[17]

However, it has been posited that a CAS possesses the ability to modify its deep structure of connections. Control mechanisms are the means through which the system's GTYPE configuration of connections is modified through past experience and anticipation of future consequences of current action. Control mechanisms affect the system's control parameters, and thus its subsequent behaviors, by modifying the arrangement and configuration of connections that constitute the system's deep structure. Thus, control mechanisms operate on and modify a holon's deep structure of connections, in turn, altering the control parameters of the holon. An alteration of system control parameters modifies the system's behavior which determines how well integrated, or how adapted, the system is to its particular set of environmental contingencies and how well it is integrated into the next higher level holon (Figures 7.3a and 7.3b).

In the case of social systems, human intentionality directs the control mechanisms. This proposition will be considered in more detail in the next section. However, the basic argument under development is that the perspective derived from complexity sciences (connections, control parameters, and control mechanisms) – when coupled with the complexity propositions of Chapter 5 – provides the basis for an explanation of structure/action and part/whole dialectics. The deep structure of connections – when linked with human intentionality and the cognitive structures of organizational members through system control mechanisms – provides an approach to explaining how individual acts and actions define collective structure and, simultaneously, how the resulting structural arrangements serve to constrain and channel subsequent acts and actions. Further, these factors provide the foundation for

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[17] See Chapter 5 for a discussion of the generalized genotype (GTYPE) and generalized phenotype (PTYPE) and their relation to connectionist models.

an explanation of how complex social systems change, develop and transform over time.

Linking Connections to Cognitive Structures

Simmel (1908: 24) notes that "...any social phenomena or process is composed of two elements which are in reality inseparable: on the one hand, an interest, a purpose, or a motive; on the other, a form or mode of interaction among individuals." In other words, subjective meaning and objective structure are inseparable elements. Thus far, the model under development has focused on the objective elements – a deep structure of connections that is driven by control parameters and directed by control mechanisms. As such, the model could arguably apply to any and all CAS – including physical and natural complex systems. A critical element in efforts to integrate the complexity sciences into *social* analysis is to incorporate the concept of "intentionality."

Intentionality. Individuals (and organizations as extensions of individual will) act with a sense of intent – that is, acts and actions of individuals, whether individual or collective, have some purpose or goal. People do not, as a general rule, act in a random manner.[18] This concept of intentionality is less restrictive than the related concept of "rationality" which assumes that acts and actions are guided by some rational (whether bounded or complete,

[18]This is stated, of course, as a matter of belief – a premise – that is subject to dispute and refutation.

instrumental or technical) decision making process. Rationality may be a factor in some cases, but not necessarily all. Intentionality requires only that some purpose or end – a consequence – be expected to result from the action.[19] The results of the act or action may have unintended and unanticipated consequences; however, the act was originally motivated by some intention on the part of the actor.

The question that arises, then, is this: If individuals act in an intentional manner (i.e., actions are expected to result in anticipated outcomes), how are choices made between various conceivable actions? The premise here is that these choices are made on the basis of perceived cause-and-effect relationships between action and outcomes. These perceived cause-and-effect relationships are reflected in the individual's cognitive structure – an internal mental model that links relevant factors and variables that is utilized to anticipate and predict the consequences of a particular act or action. Thus, the "meaning" of any particular factor to an individual or group can be

[19]This is not to say that all actions of individuals and collectives are intentional. However, the realm of random and unintended acts is deemed to be rather small.

conceptualized as deriving from the perceived cause-and-effect relationships among the set of significant factors affecting the particular situation.[20]

This cognitive structuring of cause-and-effect relationships is reflected in the schema that constitutes the individual's understanding of his/her environment. Much of this line of argument stems from Tolman's (1948) early work on cognitive approaches as an alternative to the then dominant behaviorist view grounded in the stimulus-response model (Eden, 1992). This cognitive perspective has been applied to organizational studies in the areas of strategic decision-making (Axelrod, 1976; Ford and Hegarty, 1984; Barr, Stimpert and Huff, 1992), group behaviors (Bougon, Weick and Binkhorst, 1977), organizational learning (Lee, Courtney and O'Keefe, 1992), and organizational design and diagnosis (Nelson and Mathews, 1991a).

Cognitive Schema. An individual's understanding of the cause-and-effect relationships, and the consequences resulting from those relationships, at operation in the world around him/her is reflected in the individual's cognitive

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[20]This reference to actions based on beliefs about cause-and-effect relationships may seem to imply a high degree of rationality. Again, the argument is not that actions are nonrational or irrational but that an assumption of rationality is neither necessary nor sufficient to explain action. One may hope that individuals act with some degree of rationality, but the view espoused here does not *require* it. All that is required is a belief that some act will result in some consequence or outcome based on the individual's understanding of the cause-and-effect relationships affecting the situation. The beliefs about such relationships may be irrational, as may be the case of desired outcomes and "ends." Further, the choice of "means" utilized to attain the outcome or avoid the consequence may appear irrational to an outside observer. These, indeed, may be irrational. However, except in the case of mental impairment, they are intentional. The point is that individuals act with a high degree of intentionality, whether rational or not.

schema. These schema or mental models are aggregated and simplified representations of interrelated information, concepts and relationships that an individual uses to understand various situations and environments. These schema determine, to a large extent, what information will receive attention and how it will be used. Schema direct action by indicating what information is appropriate and relevant to any particular situation and by providing a basis for action founded on the understanding of the cause-and-effect relationships between those relevant factors (Nisbett and Ross, 1980). Information that does not "fit" the schema in use tends to be filtered out (Kiesler and Sproull, 1982) or interpreted in light of the current mental model. Schema may be conscious, explicit and overt or intuitive, implicit and tacit (Reber, 1989a, 1989b; Nonaka, 1988, 1991).[21] The point is that individual behavior is directed by individual understanding of relevant situational factors as represented by these mental models.

Assumption 7.5: Connections between individuals are regulated by a complex set of logic, rules and laws governing their interactions. These are reflected, and find expression, in the cause-and-effect schema utilized by individual members.

Objectivist, nomothetic and behavioral approaches stress the "real" structural aspects of acts and actions. Subjectivist, ideographic and cognitive

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[21] It appears intuitive to suggest that cognitive schema are utilized by individuals in anticipating and understanding the appropriate interactional mode and types of resources to be exchanged in any interactional sequence. The degree to which the two schema are congruent (i.e., a consensual intersubjectivity is reached), the greater the ease with which the interaction episode proceeds.

approaches focus on the "interests, purposes, motives" – the enacting of structure and the social construction of reality. The position taken here is that both are central elements in explaining structure/action dialectics. It is not a case of either/or; both objective and subjective elements are necessary to explain the processes through which actions affect structure and, alternatively, structure constrains and maintains action. The patterning of connections give rise to objective social structures which serve to define, delimit and constraint the subjective cognitive schema of individual members. Concurrently, the schema governing and regulating dyadic interactional sequences give rise to the spatial and temporal patterning of connections that serve to define, delimit and constrain the objective structural features of the organization. This reciprocal process of interplay between the subjective and objective operates through the effects of subjectively directed control mechanisms on the deep structure of connections where behavior is driven by objective control parameters.

Control Mechanisms and Control Parameters

Control mechanisms refer to those means through which organizational members can, and do, influence the deep structure of connections. *Control parameters* are the result of interactions and exchange at the level of deep structure that lead the system to the stable, complex or chaotic zones of behavior. Control mechanisms operate through the process of altering connections (based on members' understanding of system functioning as represented in their mental models) of the organization's deep structure, which in turn, affect the values attached to each of the system's control parameters. The values jointly attached to the control parameters determine subsequent system behavior and, in turn, influence the operative schema. Thus, social system behavior and structure is a result of the iterative process of control mechanisms altering and adjusting the deep structure of connections. New configurations of connections in the deep structure result in varying values attached to control parameters, leading to changes in system behaviors. These new behaviors are interpreted in light of organizational members' cognitive schema. Based on these subjective assessments, interpretations and intended consequences, further adjustment and/or alteration of the control mechanisms may be initiated, setting the cycle in operation again. Thus, human intentionality enters the process through subjective assessment and manipulations of the systems control mechanisms. Control mechanisms, however, may be either (1) formally designed and implemented (as informed by organizational level schema) or (2) informal mechanisms that emerge out of the day-to-day processes of dyadic interactions (as informed by individual level schema).

Formal Control Mechanisms. Formal control mechanisms are those that are designed, developed and implemented at the system level.[22] Three levels of formal mechanisms are posited. *First-order control mechanisms* refer to mechanisms such as direct supervision, formal procedures and policies, and formally designated structures of reporting, authority and power relationships. The primary purpose of the 1st order mechanisms is to regulate technical and instrumental resource flows through the deep structure of connections in the organization. These formal arrangements are, thus, the primary means of control over the prescribed/formal modes of interaction and the power/authority, instrumental/technical, and formal information/communication flows. In terms of a socio-technical systems perspective, these mechanisms focus on regulating the technical sub-system.

Second-order control mechanisms are directed at efforts to exert a degree of organizational control over the more informal and social aspects of connections between members of the organization. These 2nd order mechanisms may be formally designed and implemented, but the primary purpose is to regulate the social and informal relationships between organizational members (i.e., the social/informal interaction mode). Designated

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[22]This, of course, presumes the existence of an organizational level schema. The schema operating at the organizational level may be a reflection of (1) the schema of a strong, authoritarian decision maker, (2) the result of efforts to develop a consensus of opinion among top management, or (3) the result of subconscious, implicit and/or tacit interactions among those in a position to make organization-wide decisions. In any event, formal control mechanisms operate at the system level and are guided by an organizational level understanding of the current situation as reflected in the organizational level schema and an estimation of the system-wide effects of the application of specific measures.

work teams, "gripe" sessions, open door policies, etc. all fall into this category. Second-order mechanisms are designed to regulate social/informal modes of interaction and most directly impact affect/friendship exchanges and the informal aspects of communication/information exchanges, though there is also a secondary effect on power/authority exchanges. These mechanisms can be viewed as efforts to regulate the social sub-system (in socio-technical systems theory).

Third-order control mechanisms focus on attempts to regulate and control the organizational culture. These 3^{rd} order mechanisms focus on the symbolic and ceremonial modes of interaction with an emphasis on instilling an organization-wide set of norms and values. Company songs, codes of ethics, company uniforms, leadership and motivational efforts by top management, and symbolic rewards (e.g., employee of the month) are all examples of 3^{rd} order control mechanisms. Much of the potential for successful "transformational" leadership comes from attempts at manipulating 3^{rd} order control mechanisms.

These control mechanisms are listed in descending order of directness – 1^{st} order mechanism exert a more direct influence on the deep structure of connections than 3^{rd} order mechanisms. Similarly, the degree of control over outcomes resulting from attempts at manipulating these mechanisms is greater for 1^{st} order than for 2^{nd} order and 2^{nd} order greater than 3^{rd} order. First-order formal mechanisms directly alter the arrangement of connections (either by changing the modes of interaction or the flows of exchanges). Second- and third-order mechanisms indirectly modify connections through manipulation of informal control mechanisms by altering the cognitive structures (schema) of individual members of the organization. These formal control mechanisms should be viewed as existing on a continuum. No organization – except possibly informal (or very small formal) groups – relies solely on one type of formal mechanism to the exclusion of all others. All are at play, in one form or another. However, any particular organization may attach more importance to and emphasize one of the types of formal mechanisms.

Proposition 7.3: Organizational control over the deep structure of connections is greatest for 1st order formal mechanisms. Progressively less degree of control is exerted over 2nd and 3rd mechanisms.

Proposition 7.4: Choice of formal mechanism to emphasize in efforts to control and align the organizational deep structure is dependent on the dominant organizational level schema.

Proposition 7.4 suggests that the choice of formal mechanism emphasized in particular organization depends on the organizational level cognitive structure. For example, an organization that "chooses" – based on decision-makers cognitive structuring – to be more centralized, formalized and authoritarian will tend to rely most heavily on first-order formal mechanisms. Alternatively, a decentralized, informally structured and democratic organization will tend to rely more on second- and third-order formal mechanisms to direct the deep structure of connections.

Informal Control Mechanisms. Informal mechanisms are those *modes of exchange* that influence and condition the recurring micro-level dyadic exchange relationships between individual members of the organization. These mechanisms result from and emerge out of the structuring processes of day-to-day interactions among individual members of the organization. Modes of exchange may be characterized as either generalized or restricted exchange systems (GES or RES) and indicate the degree and type of reciprocity expected when resources of various types are exchanged. These generalized or restricted modes of exchange[23] are characteristic of the organizational "*interaction order*" (Goffman, 1983) which refers to those concrete, repetitive activities and interactions that characterize the daily routine of a social setting. It is this interaction order that accounts for the emergent properties of social structure. The interaction order is socially constructed (Berger and Luckman, 1967) and negotiated (Strauss, 1978, 1987) leading to relatively stable patterns of action, interaction, exchange and interpretation. From this perspective, social structure does not exist external or prior to human endeavor (Barley, 1990).

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[23]*Modes of exchange* are conceptually distinct from the *modes of interaction* and *types of flows* discussed earlier. Modes of exchange refer the *schema* governing interaction episodes where resources are exchanged. Modes of interaction provide the *context* for such exchange interactions. Flows refer to the *content* of the exchange interaction. Thus, the context (interaction mode) may be formal, informal or symbolic. The exchange mode (the dominant interaction order) indicates the appropriate degree of reciprocity and self-interest, for example, within any exchange episode.

The dynamics of the structuring dyadic interactions result from the interrelated processes of regionalization, categorization, ritualization, normatization, stabilization of resource transfers, and the routinization of activities (Turner, 1988) as discussed in some detail in Appendix A. The point emphasized here is that these structuring dynamics result in more or less stable interaction patterns among members of the social system. Out of these recurring interaction patterns and structuring processes at the dyadic level, a characteristic interaction order develops. This interaction order – characterized by a particular mode of exchange – can be characterized as being regulated according to norms governing one of two basic modes of exchange: "restricted" or "generalized" exchange modes (Uehara, 1990; Ekeh, 1974).

Restricted exchange systems (RES) are based on norms of mutual reciprocity and responsibility where parties to the exchange are motivated primarily by self-interest. The exchange relationship between individuals is formed as means to specific ends and based on the notion of a contractual arrangement, either implicit or explicit, where an immediate or short-term return is expected. Thus, there is a strong instrumental and rational (both as to means and ends rationality) element to the relationship and the resulting interaction order is characterized by a high level of individualism, competition, impersonality and contractualism that is apparent in every aspect of the connection. A RES is implicit in the transaction cost approach (Williamson, 1981, 1991) and is closely related to the notions of *Gesellschaft* posited by Tönnies and Weber, and Durkheim's organic solidarity.[24]

Generalized exchange systems (GES) are based on norms of unilateral and indirect reciprocity, where no direct or immediate return is necessarily expected in any particular transaction between actors. In a GES the relationship between individuals is valued as an end in itself. The association is often founded on the basis of friendship, kinship or affection and the resulting interaction order is characterized as more collectivist, cooperative, homogenous and cohesive. A GES is, thus, clearly related to Tönnies and Weber's *Gemeinschaft* and Durkheim's mechanical solidarity.

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[24]It should be noted that though Tönnies and Durkheim both wrote in terms of mechanical and organic solidarity, the meaning attached to each is the exact opposite of the other. For Tönnies, traditional societies are based on *Wesenwille*, or natural will, where associations are primarily governed by affective and/or kinship relations. For Tönnies, this is an organic form of structure – *Gemeinschaft* characterized by a high degree of intimacy, emotional depth, moral commitment, social cohesion and continuity. *Gesellschaft*, or modern mechanical society, is based on *Kurwille* (rational will) and is motivated by self-interest and the rational attainment of instrumental ends, not by a complex web of affective and communal times. Durkheim, on the other hand, views traditional societies as based on mechanical solidarity where all individuals are relatively homogenous and bound by the attraction of similarities and by blind acquiescence to public opinion and tradition (the *conscious collective*). In modern societies, however, where the division of labor is well developed, individuals have more diverse personalities, experiences, and functions and are bound by an organic solidarity resulting from a need for reciprocal services (the attraction of complementary differences). The paradox for Durkheim is that in a traditional society (i.e., mechanical solidarity), where individuals are less dependent on others for existence and most able to develop individuality, the *conscious collective* limited the individual's ability to assert that independence by completely enveloping the individual consciousness. Only in an organic solidarity (i.e., modern society based on the division of labor) is true individuality possible. In both cases, however, modern society is seen as more individualistic, contractual and compartmentalized than traditional society. Similar issues have found expression in Ouchi's (1980) conceptualizations of clans and bureaucracies, Merton's (1957) local versus cosmopolitan, Etzioni's (1961, 1964) normative versus utilitarian organizations, Granovetter's (1973) strong versus weak ties, and Riesman's (1950) inner versus other orientation. These issues are clearly related to current research interest into the effects and determinants of individualist versus collectivistic organizational behaviors (e.g., Chen, Chen and Meindl, 1998).

These modes of exchange relationships that characterize the interaction order should, however, be construed as "ideal types" (in a Weberian sense) and not as mutually exclusive categories – no dyadic exchange or the resulting interaction order can, in reality, be characterized as either a pure GES or RES. They are descriptive of the continuum of the potential range of modes of exchange that characterize the interaction order. However, in any particular interaction order, either a GES or RES is presumed to predominate. These modes of interaction provide the basis for the rules and logic that are incorporated into individual-level schema which control dyadic exchange interactions among members of the organization and determine the dominant characteristics of the interaction order. Thus, the rules and logic of the interaction order affect subsequent and recurring exchange interactions. The particular interaction order – and the operative informal control mechanisms – that predominates in any specific organizational system is dependent on both (1) the history of relationships among members of the organization and (2) upon the each individual member's personal history and experience outside of the organizational system.

This view of a predominant interaction order is grounded in Turner's theory of interaction and is an extension of the analytic model of dynamic interpersonal structuring (Appendix A). Turner's synthesis focuses, however, on the *dyadic* interaction. The focus here is on the joint and recurring effects of such interactions.

Proposition 7.5: The joint effect of many recurring dyadic interactions in an organizational setting is the emergence of a dominant mode of exchange. This mode of exchange characterizes the interaction order of the organizational system and provides the primary informal control mechanism linking micro-level dyadic processes to macro-level organizational processes.

The pattern and configuration of connections constituting the deep structure of the organization depend, not only on the formal organizational-level control mechanisms, but also on the informal mechanisms that arise out of the recurring, day-to-day at the micro-level of the dyadic exchange. Informal control mechanisms are dependent on the organization's interaction order as characterized by either restricted or generalized exchange modes. The dominant mode of exchange becomes ingrained in the schema of individual members serving to further legitimize, sustain and maintain the organizational interaction order. This interaction order is the primary informal control mechanism through which system behaviors is directed through its effects on the deep structure of connections.

Proposition 7.6: The operative informal control mechanisms of an organizational system depend on the interaction order (either RES or GES) that emerges out of day-to-day, recurring exchange interactions among organizational members. This interaction order is reflected in and constituted by individual level schema.

Control Parameters. The behavior of complex adaptive systems is driven by five *control parameters* (rate of flows through the system, the density of connections between system elements, the strength of those connections, the degree of influence differentials between elements, and degree of diversity of system elements). The composite effect of those parameters is to determine whether the system operates in the stable (ordered and frozen) region of the fitness landscape, in the chaotic region, or in the complex transition region between the extremes of stasis and chaos.[25] Differential rates of flows of energy, resources and information function to link the system to the wider environment. The strength and density parameters serve to define the degree of connectivity of the organization's deep structure of connections between individuals and directly influence the rate of flows. Differential degrees of diversity and influence depend on characteristics of the individual members of the organization. In combination, these parameters drive system behaviors.

Control parameters operate independently of any intentionality on the part of organizational members except insofar as control mechanisms, both formal and informal, modify the deep structure of connections among individual members. In other words, the deep structure of connections provides a link between subjective control mechanisms and objective control parameters. Control mechanisms are manipulated in order to alter the deep structure of connections that constitute the system – system functioning is directed by the control mechanisms. The particular and specific configuration of such connections resulting from an application of control mechanisms leads to variable values attached to each of the control parameters – which drive system

[25]These were discussed in Chapter 5.

behaviors. Subsequent system behaviors may suggest a need for an alteration of the deep structure of connections through the manipulation of either formal or informal control mechanisms (or both), as filtered and interpreted through organizational-level schema and/or individual-level schema. System dynamics is, thus, an iterative process. System functioning is directed by the application of control mechanisms based on subjective interpretation as represented in the cognitive structure of organization members. The system is, in turn, driven by the objective behaviors that result from the values of the control parameters resulting from a specific configuration of connections that form the organizational deep structure.

Proposition 7.7: The dynamic behaviors of complex social systems result from the interplay between the objective control parameters that drive system behaviors and the subjective control mechanisms that direct system behaviors.

The behavior resulting from the joint configuration of control parameters must, if the system is to survive, be integrated with systems (i.e., holons) at higher levels while simultaneously maintaining an internal balance between the static and chaotic zones. When a "mis-fit" between external requirements and internal functioning occurs or poor performance is noted, subjective control mechanisms are manipulated to modify, alter and adjust the internal configuration of connections. Altering the deep structural configuration of connections results in different parameter values that, in turn, drive subsequent changes in objective system behaviors. These new behaviors are interpreted (as filtered through organizational and individual schema) with respect to assessments of current environmental contingencies and control mechanisms are altered in the attempt to direct future behaviors. Thus, system dynamics is a continual process of interaction between the subjective and objective.

A Connectionist Model of Organizational Dynamics

Figure 7.4 outlines the interactions that drive and direct the spatial dynamics of organizational systems. This model posits a view of social organization as a system of multidimensional connections among individual members. The spatial arrangement of connections (i.e., the deep structure of interaction modes and exchange flows) is directed by a subjective and cognitively based set of formal and informal control mechanisms. The deep structure is driven, however, by the objective control parameters that force the system into stable, complex or chaotic temporal dynamics. Moreover, this deep structure of connections serves to link the individual actor to higher level holons and those higher levels back to individuals.

While offering a general analytical orientation that incorporates the complexity science insights[26] into CAS, the model is further specified through the development of a set of preliminary propositions. In a sense, such a presentation violates the principle of nondecomposability in that all of these processes and mechanisms operate jointly – they are essentially simultaneous

[26]The reader should keep in mind that, underlying the model presented here, are the complexity insights are developed in Chapter 5.

and inseparable, and represent a holistic entity. That point being made, however, the following propositions are organized around each of the five control parameters. Additionally, the implications of the model for the source and modality of organizational change phenomena are discussed.

Rate of Flows

The rate of flows through the deep structure of internal connections, relative to the rate of flows through connections among elements in the external environment, provides the primary link with higher level holons. This link occurs in two ways. First, if the organizational system does not import or export the appropriate types and amounts of inputs and outputs (energy, resources and information) the absolute internal rate of flow is decreased and the organization tends toward the stable/inert zone. In other words, the system must be effective in its "choice" of resource flows (i.e., the inputs from and outputs to the environment) in order to sustain an appropriate rate of internal flows. Second, to the extent that the absolute rate of flows in the external environment varies over time, the absolute rate of internal flows must be adjusted to match the absolute rate of external flows. In other words, a system operating in a rapidly changing environment must increase rates of internal flows to efficiently and effectively operate in such an environment. However, an increase in the absolute rate of internal flows tends to increase the degree of instability exhibited in the system such that the system is driven toward the chaotic zone – such systems become increasingly difficult to control.[27]

Proposition 7.8: Rates of flows link the deep structure of a complex system through both the effectiveness of resource flows and the efficiency of relative rates of flow.

Thus, system survival and success in its operative environment depends (1) on the "right" materials flowing through the system, (2) on the maintenance of an internal rate of flow that is appropriate relative to external rate of flows, and (3) on the maintenance of an absolute rate of throughput that is great enough to escape the stable zone while not so great as to push the system to the chaotic zone. Successful and adaptive systems are able to maintain a position in the complex zone, poised between the static/stable zone and the chaotic zone.

Density of Connections

Rates of flows are, in turn, largely dependent on the density and strength of connections at the focal level and on the differential degrees of influence and diversity of individual elements at lower levels. The lower the degree of connectivity[28] of the system of connections (i.e., the less dense the deep structure), the lower the rate of flows through the system and, in turn, the

[27] It is intuitive to suggest that these effects are bi-directional – not only do relative rates of flow affect the focal system, they also affect the higher level holon (i.e., environment) of which this system is a component. This follows from the implication that similar processes (control mechanisms and control parameters) drive and direct holon behaviors at all levels.

[28] The degree of connectivity, or density, is measured as the actual number of connections in the system divided by the total number of potential connections. The connectivity of any network is specified by $D = k/[n*(n-1)]$, where D = density, k = number of connections, and n = number of elements in the network.

greater the tendency toward stability and stasis. Alternatively, the greater the degree of connectivity (i.e., the more dense the deep structure), the greater the absolute rate of internal flows and the greater the tendency toward instability. Greater connectivity increases the variety exhibited by the system of connections because of multiple paths along which resources can flow. An increase in system variety enhances a potential for effective experimentation, exploration, learning and adaptation. Too much variety (i.e., too many connections), however, tends to produce instabilities and to decrease the potential for effective learning. Between these extremes is a level of connectivity where the system exhibits enough density to maintain necessary flows and variety for effective learning, but is not so dense as to encourage unnecessary disruptions and redundancies that push the system to the chaotic zone. The effective, efficient and adaptive system maintains a balance between a degree of connectivity that drives it toward the stable and static zone and a degree of density that drives the system into the chaotic zone.

In terms of social organization, the degree of connectivity is closely related to the degree of formalization, centralization and strict chains of command and authority characteristic of the system.

Proposition 7.9.1: Organizations that rely primarily on 1st order formal control mechanisms will tend to exhibit less density, or connectivity, than organizations relying on 2nd and 3rd order mechanisms.

Organizational decision-makers assess the external environment and make a subjective judgement of the dominant and critical factors at operation.[29] Based on the results of this assessment, a choice is made as to both the appropriate types of inputs and outputs required for success *and* the appropriate formal mechanisms for exerting control over the internal configuration of connections (and subsequent organizational behaviors). Such mechanisms are used in order to align those internal configurations with (subjectively interpreted and enacted) external contingencies. First order formal control mechanisms *directly* affect the density of connections by specifying, delineating and mandating appropriate organizationally sanctioned connections between members. Reliance on 1st order formal control mechanisms and direct manipulation of the deep structure of connections results in a more mechanistic and bureaucratic organizational structure. Second and third order mechanisms have a more *indirect* effect on the deep structure of connections, in that they are directed at influencing the interaction order characteristic of the system (i.e., the informal control mechanisms). Such indirect mechanisms are invoked in order to influence the informal control mechanisms by altering individual schema that constitute the interaction order and, in turn, influence the deep structure of connections. Reliance on the indirect effects of 2nd and 3rd order formal control mechanisms and the indirect manipulation of the deep structure of connections

[29] In the terminology of strategic management, this is the process of "environmental scanning."

through informal mechanisms tends to result in more organic organizational structures.

As organizations face increasingly complex, variable and uncertain environments, they tend to rely more heavily on 2nd and 3rd order formal control mechanisms. This proposition is consistent with the acknowledged difference between mechanistic and organic organizational structures and their appropriateness in varying environmental contexts (Burns and Stalker, 1961). It is also consistent with the apparent trend toward decentralized authority structures and participatory management techniques designed to enhance organizational flexibility and responsiveness. The logic of the argument implies that, when faced with increased environmental uncertainty and variability, successful organizations rely less on 1st order formal control mechanisms and place a greater emphasis on 2nd and 3rd order mechanisms.

Proposition 7.9.2: Mechanistic organizations rely on 1st order formal control mechanisms to directly influence the deep structure of connections in order to enhance stability and efficiency.

Proposition 7.9.3: Organic organizations rely on 2nd and 3rd order formal control mechanisms to indirectly influence (through informal control mechanisms) the deep structure of connections in order to enhance flexibility and effectiveness.

Stable and relatively predictable environments (i.e., a relatively "flat" fitness landscape) allow for more reliance on 1st order formal mechanisms because of the requirements for internal stability, accountability and efficiency. More complex, uncertain and dynamic environments (i.e., a "steeper" fitness landscape) require an emphasis on flexibility, responsiveness and effective adaptation to rapidly changing conditions. This is can be accomplished by shifting from an emphasis on direct 1st order mechanisms to 2nd and 3rd order mechanisms that indirectly influence the deep structure of connections through the informal control mechanisms.

Informal control mechanisms variably affect the system of connections by altering individual level schema. Changes in individual schema modify the dominant interaction order (GES or RES) which, in turn, affects the deep structure of connections. A restricted exchange interaction order (RES) should result in a tendency toward less density and connectivity (because of its inherent individualism, contractualism and competitive tendencies). A generalized exchange interaction order (GES) should tend to exhibit a greater degree of connectivity (because of its communalism, collectivism and cooperative tendencies).

Proposition 7.10.1: An organization with an interaction order (i.e., informal control mechanism) characterized by restricted modes of exchange (RES) will exhibit a low degree of connectivity and density.

Proposition 7.10.2: An organization with an interaction order (i.e., informal control mechanism) characterized by a generalized exchange mode (GES) will exhibit a high degree of connectivity and density.

Thus, an organization whose informal control mechanisms are predominantly GES should result in greater density and rates of flow through the system of connections, relative to an organization directed by informal control mechanisms that are predominantly RES. Greater diversity and rates of flow imply greater flexibility and responsiveness while lower rates of flows and degrees of diversity imply greater stability and efficiency.

Strength of Connections

However, informal control mechanisms affect not only the density of connections in the organization's deep structure but also the strength of the connection between individual members. The strength of connections between elements is related to system behaviors in that strong connections tend to move the system toward efficiency, stability and reliability of performance, while weakly connected systems tend toward redundancy and instability. Strong connections set up paths that canalize flows and propagate fixed behaviors throughout the system contributing to frozen, static behaviors. Alternatively, weakly connected systems, though not as efficient, are generally more responsive and flexible.

The functioning of informal control mechanisms may have effects on the strength of connections similar to those of 1st order formal mechanisms, but the process is different. Formal 1st order mechanisms mandate and prescribe (and, perhaps, proscribe) appropriate connections and their strength. Informal control mechanisms decentralize the decision-making process by allowing individual members a measure of discretion and authority in the choice of exchange partners. Individuals who are "strongly" connected will tend to "choose" each other in recurrent exchange interactions. This tends to canalize flows, encourage the formation of cliques and promote structural inertia. Weakly connected systems are not as subject to such inertial effects because individuals retain a degree of flexibility in the choice of exchange partners thus limiting the potential for the canalization of flows. Thus, strongly connected networks are more subject to inertial effects than are systems where individuals are weakly connected. This line of reasoning is consistent with Granovetter's (1973, 1982) theoretical perspective on the differential effects of strong versus weak social ties and their effects on communication flows through social systems and with Weick's (1977, 1979) conceptualization on loosely coupled systems.

Proposition 7.11.1: An organization with an interaction order (i.e., informal control mechanism) characterized by a restricted exchange mode (RES) will have a preponderance of weak connections.

Proposition 7.11.2: An organization with an interaction order (i.e., informal control mechanism) characterized by a generalized exchange mode (GES) will have a preponderance of strong connections.

Strong connections tend to establish strong temporal dependencies that encourage inertial behavior by canalizing flows. As Dale and Davies (1994: 3) note:

> A recurrent theme throughout the social sciences is that behavior is characterized by strong temporal dependencies. Thus the decision to quit a job, to divorce, or to migrate depends upon the interval since commencing the job, marrying, or previously moving. How a person votes, the brand of food purchased, or the mode of transport for travelling to work...depends upon the choice made on the previous occasion. The former are examples of *duration dependence* while the later are examples of *state dependence* (or, more formally, 'Markov' effects)...Most of the factors creating such temporal dependencies generate inertial effects in behavior. These include social, economic,

> and community ties which progressively inhibit change and prompted McGinnis (1968) to propose an 'axiom of cumulative inertia' for social processes. Similar but involuntary dependencies may arise through constraints created by previous choice (Dale and Davies, 1994: 3).

The paradox is that while a RES interaction order tends to move the system toward stability by limiting the density of the connections and rates of flows, it simultaneously pushes the system toward instability by encouraging the formation of weak connections. On the other hand, a GES encourages the formation of strong ties that move the system toward the stable zone of behavior but, simultaneously, it tends to increase the density and connectivity of the system that can move the organization in the direction of the chaotic zone. Together, these propositions suggest that care be taken by organizational decision-makers utilizing 2nd and 3rd order formal control mechanisms to (indirectly) influence the deep structure of connections and system functioning by altering the informal interaction order. The effects of informal control mechanisms on the organization's deep structure (and resulting control parameters) are variable and difficult to ascertain in advance because of their differential effects (through altering both the strength of connections and the degree of connectivity of the deep structure of the organization).

Degree of Diversity

The control parameters considered to this point (rate of flows, density of connections and strength of connections) reflect system wide characteristics. The final two parameters (differential degrees of diversity and influence) reflect characteristics of individual members, relative to the deep structure of connections. Differences among individual members with regard to the diversity of functions and contributions affect system behaviors by increasing the requisite variety necessary to respond to pressures for change. Systems composed of members with similar attributes, abilities and characteristics tend toward excessive cohesiveness, stability and stasis. However, too great a degree of diversity among members suggests that there is no common ground for creating the intersubjective understanding necessary to sustain recurring interactions and tends to drive the system toward instability and the chaotic zone. An increase in the degree of diversity among organizational members increases the difficulty in developing and sustaining a degree of intersubjectivity in individual level cognitive schema. To the extent that such intersubjectivity is not reached, the more likely that an RES interaction order will emerge. Thus, greater diversity increases the likelihood of informal control mechanisms that lead to less a less dense and less strongly connected deep structure. These characteristics result in the variable behaviors noted above. Alternatively, a decrease in the degree of diversity (i.e., an increase in member similarities) increases the potential for a GES interaction order. Informal control mechanisms dominated by GES modes of exchange tend to result in greater density and strength of connections.

Proposition 7.12.1: An increase in the degree of diversity of abilities, perspectives and contributions of individual members tends to increase the potential for flexibility and adaptability in the deep structure of connections. A decrease in the diversity of abilities, perspectives and contributions of individual members tends to increase potential for stability and reliability in the deep structure of connections.

Proposition 7.12.2: An increase in the degree of diversity of abilities, perspectives and contributions of individual members tends to increase the potential for instability and variability in the deep structure of connections. A decrease in the diversity of abilities, perspectives and contributions of individual members tends to increase the potential for stasis and inertia in the deep structure of connections.

At some point between the extremes of too little diversity and too much diversity, lies the region where the system of connections has enough diversity to provide the requisite variety necessary for effective learning, experimentation, exploration and adaptation but not so much variety as to cause anarchy. Thus, system behaviors depend (in part) on the fitness contribution of individual elements as represented by the degree of diversity among individual members and on the combined contribution of all members.

Influence Differentials

Differential degrees of influence among members of the organization also affect system behaviors. Influential members tend to attract resource flows and contribute to the formation of strong connections with other members that can canalize those flows. The degree of influence, then, is closely related to the degree of centrality to resource flows through the organizational deep structure. The more central to those flows, the more influence. Influences differential among organizational members may result from either formal or informal control mechanisms. This view of the multiple bases of influence, power and authority is consistent with the well-known typology proposed by French and Raven (1959). The point is that influential members tend to attract flows to themselves and subsequent system behavior is canalized and stabilized. Systems with a few very influential and powerful members tend to in a more hierarchical structure of authority and power relationships. This tends to drive the system toward the stable zone of behavior. Systems where influence, power and authority is relatively equally distributed among members will tend to exhibit more flexibility and responsiveness, but may be driven toward the unstable or chaotic zone.

Proposition 7.13.1: An increase in the differential degrees of influence, power and authority will tend to increase the potential for stable and reliable system behavior. A decrease in influence differentials will tend to increase the potential for flexible and adaptive system behavior.

Proposition 7.13.2: An increase in the differential degrees of influence, power and authority will tend to increase the potential for stasis and inert system behavior. A decrease in influence differentials will tend to increase the potential for unstable and chaotic system behavior.

These propositions are consistent with, and provide a theoretical explanation for, the trend toward decentralized authority structures and participatory management techniques designed to enhance organizational flexibility and responsiveness. They also, however, point to the potential adverse effects of such a trend (i.e., an increased potential for instability and chaos).

Sources of Organizational Change

It should be apparent that the effects of each control parameter are variable. Depending on the specific value, each parameter may drive the system to either the stable/static zone or toward the unstable/chaotic zone.[30] To further complicate matters, however, it is not the *individual* effects of each control parameter that are of primary importance; it is *the joint configuration of all the parameter values that drive system behaviors.* These objective, observable and experienced behaviors (the objective environment) that drive system behaviors are linked to control mechanisms by the cognitive schema of members that directs system behavior. These control mechanisms direct subsequent system behaviors by altering, modifying and rearranging the configuration of connections based on a subjective understanding of the relationships among all significant variables (the enacted environment). From a connectionist perspective, then, the "true" source of organizational dynamics is not found at either the macro or micro levels; neither is it solely dependent on the objective or subjective aspects of organizational life. Rather, the source of temporal dynamics results from the spatial intersection of all four elements (Figures 7.5 and 7.6).

The analytical connectionist model of organizational systems developed here suggests that system dynamics (i.e., variations in the deep structure of

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[30]This is a result of the nonlinear relationships between control parameters and objective system behaviors. See Chapter 5 for references that discuss these aspects of the effects of inherent nonlinearities on subsequent behaviors.

connections) may result from either internal or external sources (Figure 7.7). Externally generated pressures for change may come from either changes in the content of external flows or from changes in the rates of external flows. Changes in either contingency result in less efficient and effective system functioning. The causes and effects of such externalities are interpreted, filtered and enacted through organizational and individual level schema, resulting in changes in formal and informal control mechanisms, thus modifying the deep structure of connections that drive subsequent behaviors.

Alternatively, variations in the deep structure of connections may derive from solely internally generated pressures, irrespective of externalities. Misunderstanding or misinterpretation of external contingencies may lead to changes in organizational level schema that alter formal control mechanism and modify the organization's deep structure. Changes in formal control mechanisms, again instituted without regard to external factors and designed to enhance internal operations, may have unintended and unanticipated consequences. These consequences may have either beneficial or detrimental effects. Changes in individual level schema may lead to changes in informal control mechanisms that direct the system of connections. Changes in these informal mechanisms may result in variations in the deep structure and to changes in the parameters that drive system behaviors. These new behaviors, again, may either be beneficial or detrimental to system functioning. To the extent that these variations in the deep structure of connections result in beneficial behaviors, the variations are selected and retained. The primary point is, however, that such variations are not the sole result of either externally or internally generated pressures – either may provide the source.

Modality of Change

The modality of change inherent in the incorporation of such variations into the deep structure is, likewise, not an either/or proposition. It is neither a gradual/evolutionary nor a punctuated/revolutionary process – yet it is both. The process of organizational change is hypothesized to proceed according to the dissipative structures approach outlined in Chapter 5. Over time, as environmental contingencies change, the deep structural arrangement and configuration of connections is incrementally modified and altered based the operative organizational and individual level schema that underlie the formal and informal control mechanisms (developmental change). The developmental change process relies on exploitation learning and focuses primarily on increasing organizational efficiencies. At some point, however, gradual and evolutionary modification to the system of connections is no longer sufficient to maintain efficient and effective system functioning – a bifurcation point is reached where punctuated, transformational and/or revolutionary variations in the deep structure are necessary to maintain and sustain system viability (transformational change). Such transformations require exploration learning in order to experiment with new deep structural arrangements so that the organization can operate effectively given the degree of misalignment with external contingencies.

On the other hand, this point of bifurcation may be reached solely as a result of internal system characteristics (i.e., changes in organizational or individual schema that modify the control mechanisms, alter the structure of connections, and change system behaviors). These internally generated bifurcations alter system behaviors that, in turn, affect the higher level holon of which the focal system is a component. Thus, internally generated variations may affect, not only the system's behaviors, but also the characteristics and contingencies of the environment in which it operates.

Conclusions

Traditional explanations of organizational change processes are limited in several fundamental respects. For example, most views on temporal dynamics conceptualize the process of change (whether evolutionary or punctuated, or developmental or transformational) as a linear and sequential process. Following Chandler's (1962, 1977) analysis of the historical development of corporate structures, managerial strategies and the operative environmental characteristics, it has been common to view the relationships between the three elements in one of two ways.

Environment→Strategy→Structure

Environment→Structure→Strategy

In the first case, changes in environmental contingencies are reflected in changes in an organization's strategies formulated to take advantage of external opportunities and guard against external threats. Changes in organizational strategies imply a necessity for changes in organizational structures so that an equilibrium is maintained between internal and external contingencies. Such changes in structure are intentionally and rationally implemented so that structure, strategy and environment are all aligned. It is usually maintained that such an alignment (i.e., equilibrium state) is necessary or organizational performance will suffer.[31]

In the second case, changes in the environment directly affect the internal structural arrangements of the organization. As external factors change, internal structural arrangements become increasingly misaligned (i.e., a state of disequilibrium exists). Two distinct views on the results of this misalignment are commonly asserted. From an ecological perspective, organizational structures are assumed to be relatively inert and resistant to change. Thus the misaligned structure becomes increasingly unable to compete given the new environment and new structural forms emerge (i.e., are born) that can compete more successfully. In time, the new forms are selected out and the old structures and forms die out because they are unable to adapt quickly enough. From a strategic choice perspective, even if it is true that

[31]This view is commonly expressed in most textbooks on strategic management. See, for example, Wheelen and Hunger (1998).

organizational structures are relatively resistant to change and serve to limit strategic choice, organizational decision-makers develop strategies based on the strengths of the old structure. These new strategies can maintain a competitive position while slowly and incrementally adjusting structures so that they align more closely with the new environment.

Thus, from each perspective, internal change is predicated on external change and proceeds sequentially through a chain of logic based on the maintenance of a dynamic equilibrium between internal and external contingencies. The change processes proceed linearly and system success and survival depends on the maintenance of a state of equilibrium (either among internal elements or between internal and external elements). No attention is given to the proposition that change may be internally generated. No attention is given to the proposition that the states of disequilibrium may be responsible or required (at least in part) for differential rates of organizational success. And certainly, no attention is given to the proposition that the temporal processes of organizational dynamics proceed as an iterative and dialectic process among macro and micro, objective and subjective forces. A connectionist perspective provides the first step toward an adequate model of the dynamics of complex systems that integrates each of these elements.

The analytical model presented in this chapter outlines the general elements and interactions that form a connectionist perspective on organizational developmental and transformational change processes. This complexity science and CAS perspective on organizational dynamics is most properly considered provisional and exploratory, subject to empirical and experimental verification. It does, however, propose a potentially valuable perspective and establishes a viable research agenda for further explorations of the links between the complexity sciences and the organizational sciences.

CHAPTER 8

CONCLUSIONS

This research project developed a theoretical approach to the study of organizational dynamics that integrates implications of the complexity sciences, while remaining grounded in current knowledge of organizational and social processes. A CAS connectionist model is proposed as a perspective that links emerging insights on the behaviors of complex physical and natural systems to explanations of the complex dynamic processes of social systems. The need for the research is premised on the argument that theoretical integration is a necessary prerequisite to empirical analysis and is a critical requirement before attempts at applying complexity insights and implications to managerial and applied problems. Thus, the project focuses primarily on the problem of conceptual and theoretical integration. This purpose, however, does not suggest the need to develop an entirely new perspective to replace current approaches. Rather, it suggests that the complexity approach should be used to extend and enhance current understanding.

The theoretical and conceptual task of integration was pursued using a deductive research strategy to develop an analytical model of organizational dynamic processes. The chapters in Part I developed arguments to support this strategy, defined the crucial issues involved in developing a model of change processes, and introduced the complexity sciences. Part II compared and contrasted "traditional" science to the complexity sciences. Chapter 4 characterized traditional approaches as founded on fundamental assumptions derived from a Newtonian/Darwinian worldview. Chapter 5 developed alternative implications that follow from emerging research into the behaviors of complex physical and natural systems and contrasted them to the implications of traditional science. Though the complexity perspective – as an interdisciplinary science – covers a wide range of theoretical approaches, the implications from these collective approaches are becoming integrated into, and best represented, by Complex Adaptive Systems theory and its underlying connectionist perspective (Figure 3.1). In Part III, these alternative implications were applied to problems of concern to organizational researchers as indicated by a review of the relevant literature.

Part III suggests that the complexity sciences offer much more than analogical and metaphorical benefits, in terms of explaining and understanding organizational dynamics, for the organizational sciences. The complexity sciences promise, especially with regard to complex adaptive systems and the connectionist perspective, a fundamentally different approach to the understanding and analysis of organizational phenomena. This approach suggests a pragmatic resolution of problems at the metatheoretical and paradigmatic level (Chapter 6). The connectionist model developed in Chapter

7 offers an approaches that promises to enhance and extend an understanding of organizational dynamics at the level of substantive theory.

The general conclusions of the connectionist perspective are summarized in the next section of this concluding chapter. A second section presents some preliminary implications for applied issues. Finally, the methodological implications are briefly discussed.

General Conclusions

Prediction and Control

In Chapter 6, metatheoretical issues were addressed in terms of the paradigm incommensurability thesis. The general conclusion reached is that both objective/nomothetic and subjective/ideographic approaches to the understanding of social phenomena are "right." This apparent paradox can be resolved insofar as disagreement over the possibility of prediction and control (*Verstehen* versus *Erklären*) represents the pragmatic result of the underlying philosophical issues. These underlying philosophical and metatheoretical issues have remained unresolved for millennia and may never reach an ultimate resolution. However, the basic and pragmatic orientation of proponents on each side determines a view as to the ultimate purpose of social scientific discovery: either the purpose is one of explanation resulting in an ability to predict and control social phenomena or that the only realistic purpose is to produce a more complete understanding social complexities. The implications developed in Chapter 5 propose that – as a pragmatic matter – prediction and control may remain beyond the realm of possibility. This is true although there is an underlying nomothetic structure to "reality" and such natural laws are discoverable (an objectivist position). On the other hand, just because system behaviors cannot be predicted and controlled over any appreciable time frame (as implied by the subjectivist position) does not lead to a necessary and inevitable conclusion that no such nomological structure exists. To the contrary, such indeterminacy may in fact result from those fundamental laws rather than from the indeterminacy of history or from human free-will and choice.

At the level of substantive theory, an analytical model of organizational dynamic processes was posited that integrates the implications developed in Chapters 5 and 6 into contemporary approaches to social behaviors (Chapter 7). A view of social phenomena resulting from networks of interacting agents and dyadic exchange as the fundamental unit of social analysis has an apparent and obvious analog to the connectionist perspective on the behaviors of complex adaptive systems. These (i.e., connections of individuals in social systems and connections of elements in CAS) provide the theoretical point of intersection between the social sciences and the complexity sciences. Further, the connectionist model of organizational dynamics developed in Chapter 7 (Figures 7.4 and 7.7) indicates a way in which intentionality and human choice can be integrated into a complexity science perspective. The analytical connectionist model, thus, extends and integrates the CAS approach to explanations of physical and natural system behaviors to an integrative perspective on the dynamics of social and organizational systems.[1]

Subjective/Objective Integration

The elements on the left side of the model (the control parameters in Figure 7.4) are based on complexity science insights in general and the CAS approach in particular. The elements on the right side of the model (the control mechanisms) are grounded in the social and behavioral science literature. The deep structure of connections provides a link between control parameters and control mechanisms. The control parameters of the model represent the objective features of social and organizational life. The control mechanisms represent the subjective features of the same. That is, control parameters operate according to invariant "natural" laws that serve to drive system behaviors. That is, objective forms of system behaviors are the result of the specific pattern and configuration of connections in the system's deep structure.

[1]To be more explicit about the logic of the argument, the contention is that the insights and implications of the complexity sciences provide the basis for the CAS approach. Viewing a complex adaptive system as a collection of interacting agents suggests a connectionist perspective and shifts the focus away from the agents themselves to the connections between those agents. From the social sciences, social behaviors are posited to have their root in interactions among individuals. By focusing, not on individual characteristics, but on dyadic interactions, one can view a social system (i.e., organization) as a complex network of dyadic interactions having both cognitive and structural components. By shifting attention from either the individual/cognitive/subjective or the structural/objective aspects of social phenomena, to a focus on the connections themselves, allows for the link with CAS and the complexity sciences. Thus, the model integrates a cognitive component, an interactional component, a structural component and a CAS perspective into a connectionist approach to a description of the processes of organizational dynamics.

The control mechanisms that direct system behaviors are manipulated (either consciously or subconsciously) by human intentionality and understanding according to relatively malleable "social" laws as invoked through the cognitive schema of individual members. That is, the "rules" and "laws" that determines the specific pattern and configuration of connections are subject to, and result from, subjectively informed human intentionality. Thus, the metatheoretical and paradigmatic issues (and their proposed pragmatic resolution) are reflected in the analytic model. Both subjective and objective elements are required for an adequate understanding of social dynamics – neither approach (nomothetic or ideographic) can adequately account for the complexity and richness of social phenomena without reference to the other. Thus, neither approach is "right" – nor is it "wrong." Each, by itself, offers only a partial explanation.

Macro/Micro Integration

Similarly, the connectionist model offers the potential for resolving the problem of linking micro- and macro-level phenomena that has for so long plagued the social sciences. The bottom portion of the model (Figure 7.4) represents micro-level interactions, the upper portion macro-level. A conceptualization of social organization as a deep structure of multidimensional connections provides a theoretical explanation of the mechanisms through which micro and macro are linked. The model suggests neither that macro-level dynamics result solely from aggregated micro-level interactions nor can macro-level explanation be reduced solely to micro-level phenomena (and studied according to the *doctrine of methodological individualism*). Neither does it suggest that micro- and macro-levels represent entirely distinct and separate levels of social "reality" (and studied with respect to the *principle of isomorphism*). The model does suggest that neither macro-level nor micro-level phenomena can be explained solely on its own terms, without reference to the other. Both are necessary for an adequate theoretical explanation of social dynamics.

Sources and Modalities of Organizational Dynamics

In either case – subjective and objective, macro and micro – the deep structure of connections provides the link that allows for theoretical and conceptual integration. In doing so, the model has definite implications about the source of those dynamics – either one *or* both factors (internal and external) may provide the source. Moreover, organizational dynamics are neither fundamentally developmental nor transformational. Both dynamics (gradual/evolutionary and punctuated/revolutionary) are typical of social system behaviors. Thus, neither can be characterized as dysfunctional. The timing of the onset and duration of each temporal process is, however, a function of the context, the situation, the system's history and the specific configuration of any particular deep structure of connections.

It should be obvious that the *leitmotif* – the dominant theme – of this research project is that CAS provides a perspective that suggests a way of resolving many of the apparent paradoxes, contradictions and controversies in organizational studies. It is in this sense that the complexity sciences offer – not an alternative to replace contemporary perspectives – but a paradigm that extends, enhances and provides an integrating approach to social and organizational studies. This is the "paradigm shift" that results from an incorporation of a complexity science perspective into organizational theory. Organizational researchers must abandon "either/or" perspectives and theories and move to the recognition that the complexities of social phenomena require perspectives and theoretical approaches that incorporate "both" into explanations.

Theoretical Adequacy

The model presented here is admittedly provisional and general but in a sense that is the point – a model developed to explain general and invariant mechanisms must, of necessity, deal with general concepts and constructs. Analytical modeling allows for the inclusion of greater complexity in developing an understanding of social phenomena. However, this goal of increased comprehensiveness (i.e., the development of more "realistic" models) should not be pursued to the abandonment of parsimony. Analytical models are useful in "...extracting the key elements of phenomena that are mutually embedded in the empirical world and in suggesting the propositions that can explicitly denote the crucial causal forces behind this embeddedness" (Turner, 1988: 175-76). The key is to utilize the analytical modeling technique to meet the evaluative criteria of *comprehensiveness* and *coherence* while, simultaneously, not violating the principle of *parsimony*. Once evaluated on these three criteria, the proposed theoretical model can be subjected to empirical examination to evaluate the model's *correspondence* to observed data and judged as the *pragmatic* benefits of application in practical situations.[2]

In some sense, however, the analytical model posited in this project violates the complexity science implication of nondecomposability. If not violate, it at least presents a paradox in that the analytical connectionist model decomposes what is avowed to be a holistic entity. However, it should be kept in mind that, though the elements are analytically decomposed, they are in actuality a whole and cannot be studied in isolation. The purpose of analytical decomposition (as opposed to empirical decomposition) is to demonstrate the internal logic of the model (coherence). Further, the model is specific (parsimonious) enough to suggest avenues for future research but general enough to be applied in various organizational and social settings (comprehensiveness).

Implicit in the connectionist model of organizational dynamics presented in Chapter 7 are all of the complexity implications outlined in Chapter 5. However, the complexity implications can be made more explicit and, in this

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[2]See Chapter 1 for a brief discussion of the five evaluative criteria used to judge theory and proposed theoretical approaches. The primary concern in this project is with the first three criteria (comprehensiveness, coherence and parsimony). However, it is undeniably true and acknowledged that, ultimately, the theoretical approach must also meet the criteria of correspondence and pragmatic results to be of any value to researchers and practitioners.

explication, the issues developed in Chapter 2 (driver, director, source, modality, process, history and context) can be linked more clearly to the connectionist model. The next section suggests some implications of the connectionist perspective for two areas of applied studies: the dynamic processes of organizational development and transformation and the process of providing strategic direction for organizational systems.

The Connectionist Model and Organizational Implications

The connectionist model of organizational dynamics presents an analytical cross-section of the critical elements that drive and direct organizational dynamics. However, the question must be addressed of how these elements play out over a temporal dimension. The proposed temporal dynamics can be descriptively related, in anticipation of empirical testing and verification, by a consideration of three phases in the developmental and transformational dynamics of system change (Table 8.1). The dynamics of each phase, which are grounded in the connectionist model, are linked to the dissipative process as described in Chapter 5 (Figure 8.1).

Development and Transformation

Phase 1: Organizational Founding. A new organization is founded by an entrepreneur (or entrepreneurial team) to pursue some hypothetical opportunity. Based on his/her understanding of the opportunities presented by the current economic environment (as reflected in the individual's cognitive schema), the entrepreneur hires a workforce, designs an operational strategy, and establishes suppliers and outlets for the proposed product/service. These elements are incorporated into an initial plan of action. In implementing the action plan and establishing an organization to pursue these activities, the initial system of connections is established. This is premised, of course, on the notion that organizations – in and of themselves – "do" nothing. Rather, organizational activities are carried out and organizational goals pursued through the collective actions of individual members and, furthermore, that these collective activities are accomplished through the multi-dimensional system of connections between members. These establish the initial conditions (internal and external) under which the organization is founded.

In order to survive, the initial deep structure of connections must attain some measure of equilibrium. This equilibrium must occur, both internally with respect to rate of flows through the system of connections (absolute flows), and externally with respect to rate of flows in the general and task environments (i.e., relative flows).[3] Flows link the deep structure of organizational

[3]Implicit in this view is the idea that functional activities are most significant in their effects on rates of flow. For example, marketing efforts alter the rate of flow of finished goods and services. Information technology alters the rates of information flow. Operations and logistics management alters the rates of flow of raw materials and work-in-progress. The financial function alters the rate of financial flows. These functional activities are manipulated (i.e., controlled) primarily by 1st order formal mechanisms. At the same time, the social and symbolic aspects the connections affects the rates of flow. These flows are manipulated (controlled), to some extent, by 2nd and 3rd order formal mechanisms (and are generally the province of the human resource function).

connections to the external environment through exchanges of resources and information (both as inputs and outputs). If the appropriate information and resources are not input and output, the flows between the environment and the system – and through the deep structure of internal connections – are slowed to the extent that the organization does not meet survival criteria. This suggests that either not enough negentropy is imported to offset the internal maintenance needs and/or not enough output is generated to support current and future activities. On the other hand, the rate of internal flows must not be so great as to encourage internal disruptions (i.e., move the organization into the chaotic zone).

To survive this formative period, the initial structure of connections – directed by both formal control mechanisms with respect to overt cognitive schema and informal control mechanisms with respect to the interaction order and the tacit schema of organizational members – must jointly optimize absolute and relative rates of flows. The flows through the internal system cannot be too tightly controlled as to inhibit response (leading to stasis and inertia) nor too loosely structured as to lead to chaos and dissolution. Further, no matter the internal considerations that affect the rate of flows through the connections (as directed by both formal and informal mechanisms) the flows must correspond to external requirements (rate of flows in the external environment). That is, an appropriate rate of flows, relative to the rate of environmental flows, must be established such that a state of equilibrium is established between external requirements and internal configurations.

This arrangement establishes an initial configuration of control parameters (rate of flows, strength and density of connections, degree of diversity and influence differentials between organizational members). These parameters drive the system to exhibit some objective behavior. This behavior is assessed (as filtered through the formal decision-makers' cognitive schema) and actions may be taken to adjust the deep structure of connections to alter the rate of flows through the organizational system. However, such adjustment depends, not only on formal control mechanisms, but also on the emerging interaction order that constitutes the informal control mechanisms of the organizational system. These informal mechanisms may serve to direct the system of connections in coordination with formal efforts. On the other hand, informal mechanisms may serve to direct the system of connections in ways that are opposed to and in conflict with formal organizational efforts to direct system behaviors.

In this initial period of connection development, the organization is particularly vulnerable to disruption. The configuration and structure of connections depends on both formal control mechanisms (as informed by the organizational level cognitive schema) and informal control mechanisms (as informed by the cognitive schema of individual members as reflected in the informal interaction order). However, the joint effects of both types of control mechanisms have not stabilized or rationalized. Because of the newness of the deep structure of connections, the effects of different configurations of connections on system control parameters are not well understood. Moreover, the system of connections has not had time to stabilize (i.e., the flows have not been sufficiently canalized). Thus, in this initial formative phase neither the (1) control mechanisms (formal and informal) nor (2) the configuration of connections has stabilized. This suggests that the paths of flows through deep structure have not sufficiently canalyzed.

The source, or impetus, for organizational dynamics in this formative phase may thus result from a mismatch between internal flows and external flows (perhaps because of faulty analysis and limitations in the cognitive schema of organizational members – i.e., contextual and cognitive factors), changes in the external rate of flows (because the deep structure of connections has not stabilized to the point of being able to react/adapt effectively – i.e., processual factors), or from the parameter values that push the system to chaos and dissolution (where the strength and density of connections or the degrees of influence and diversity of members are not sufficient – i.e., historical factors). The organization is subject to the "liability of newness," primarily because of the lack of canalization and internal coherence. The initial period of system formation is characterized by a reliance on exploration learning mechanisms while the deep structure "learns" the most efficient and effective manner of configuring the system of connections. Experimentation with alternative configurations seeks to optimize flows, with respect to both relative rate of flows (external requirements) and absolute rate of internal flows (to maintain a position in the complex zone of behavior between chaos/disruption and stasis/stability).

Phase 2: Organizational Development. As the organization learns to function in its operative environment (context), the linkages between particular configurations of connections, the resulting values of control parameters, and the requirements of the environment are assessed and internalized though subjective assessment. This occurs both at the formal level (formal control mechanisms/organizational level schema) and the informal level (informal control mechanisms/interaction order). Flows through the system of connections become increasingly canalyzed and rationalized (i.e., the connections become institutionalized). In the developmental phase, exploitation replaces exploration as the primary learning mechanism. This is the period of convergence, developmental, incremental and morphostatic change. System dynamics (as driven by the control parameters), in this period, may be amenable to relatively high degrees of prediction and control (through the explicit manipulation of formal control mechanisms). Changes in external rates of flows may produce temporary misalignment, but equilibrium conditions can be restored by judicious manipulation of formal control mechanisms to alter the deep structure of connections. To the extent that these manipulations are effective, internal flows are "optimized" such that the system maintains a position in the complex region

However, even in this period of relative stability, the system can be jolted by unexpected contextual changes. These either may be internally generated (changes in the informal interaction order and informal control mechanisms) or externally generated (abrupt changes in rate of external flows). Because the organizational system is posited to exemplify a CAS, small changes in system parameters may result in unexpected and unanticipated changes in system behaviors (Complexity Implication 1).[4] Further, though the system may exhibit a degree of predictability (weak chaos) resulting from its underlying deterministic and nomothetic structure its behavior is unpredictable over longer time frames (Complexity Implication 2).

Moreover, many of the unintended and unanticipated effects of attempts to manipulate control mechanisms (both formal and informal) are a consequence of attempting to analyze the holistic and essentially nondecomposable system solely in terms of constituent components (Complexity Implications 3 and 4). The suggestion is that, even in this period of relative stability and predictability, the system may be subjected to internally generated disruptions that alter system parameters such that it is driven from the complex region to either the chaotic or static regions of functioning.

[4]This is because the connections between system elements are a combination of linear and nonlinear functions. Further, the system of connections consists of a number of negative and positive feedback loops.

Phase 3: Organizational Transition. Over time the flows through the deep structure of connections develop historical patterns and become so institutionalized (i.e., canalyzed) that structural inertia becomes a concern. At this stage, the organization may be prone to inertial effects such that it is no longer responsive to changes in environmental (i.e., external) rates of flows. This inertia, however, is not explained by forces operating at the environmental level (as in ecological arguments).[5] To the contrary, the connectionist perspective suggests that inertial forces are the result of endogenous processes relating to the functioning of complex adaptive systems. In this period of increasing misalignment, exploitation learning becomes less efficient and marginal adjustment in the existing structure of connections (developmental and incremental change) becomes less effective (because of the canalyzation and the resulting inertia). The initial conditions under which the system of connections were formed, the history of the system of connections and the contextual (as filtered through the cognitive schema of organizational members) factors dealt with in the interim all contribute to this canalyzation and inertia.

At some point, the internal rate of flows becomes so misaligned with the rate of external flows (i.e., a disequilibrium occurs) that the system of connections enters a period of symmetry breaking and transformation where

[5]For example, Hannan and Freeman (1984: 149) argue that "...high levels of structural inertia in organizational populations can be explained as an outcome of ecological-evolutionary processes." The connectionist perspective argues that the sources of such inertial forces are endogenous to the system and internally generated.

system functioning is neither effective nor efficient. At this point, the system must change emphasis from exploitation learning to exploration learning in order to experiment with new modes and configurations of connections.[6] This period of upheaval is not dysfunctional, in the sense that it must be avoided at all costs. To the contrary, such a period of instability is necessary if the system is to transform the deep structure of connections and move to a "higher" level of functioning where is can deal external contexts and contingencies more effectively and efficiently (Complexity Implication 5).[7] This is the period of divergence, transformation, revolution and morphogenic change. The resulting structural configuration of connections that emerge from this period of upheaval (i.e., after the bifurcation point) are theoretically unpredictable. Thus, while the degree of predictability is moderate in Phase II, it is extremely problematic in Phase III. Even if the history, specific contexts, and development processes that led the system to this point of bifurcation are completely known and understood, the prediction of what arrangement and configuration of connections will replace previous arrangements and configurations are unknown and unknowable. In a sense, this new configuration of connections represents a "new" organizational form. If, during this period of transition,

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[6]The implication here is that this change from exploitation to exploration learning must occur with respect to both formal and informal control mechanisms.

[7]The argument here is not that the organizational system necessarily becomes more complex after the bifurcation or transformation. The structure may, in fact, become *less* complex. The critical issue is whether the new (or emergent) structure and configuration of connections is better able to maintain a position in the complex region of behavior.

exploration learning is ineffective in "discovering" a new and appropriate configuration, or if the organizational system persists in efforts at exploitation learning (modifying existing buffering and dampening mechanisms), the organization does not survive.

The dynamics of these processes are illustrated in Figure 8.1, which is an extension of the dissipative process illustrated in Figure 5.3. The clear implication of this perspective is that organizational systems proceed through differing phases of development and transformation, but that the dynamics of the developmental and transformational cycles cannot be explained solely with reference to either external or internal factors. Only with the inclusion of internal/external, macro/micro, and subjective/objective elements can these processes be adequately explained.

Strategic Direction

The connectionist model of organizational dynamics can be linked to approaches to the process of establishing the strategic direction for organizational systems. *Strategic planning* (e.g., administrative school), *strategic management* (e.g., the design school) and *strategic learning* (e.g., the emergent school or logical incrementalism) have each been proposed as modes for formulating strategy and establishing long-term direction for the organization (Mintzberg, 1990; Ansoff, 1990; Barr, Stimpert and Huff, 1992; Slater, 1995; Quinn and Voyer, 1998). Though strategic planning mode has been largely abandoned by researchers and academicians in favor of a strategic management mode, it remains the dominant approach in many organizational settings (Wheelen and Hunger, 1998). The implications of a complexity approach suggest a need to examine more closely the implications of strategic learning (Phelan, 1995; Stacey, 1995, 1996b). Table 8.2 and Figure 8.2 illustrate how the issues developed in this research project are related to each of the modes.

Strategic Planning. The "planning" mode is characterized by an emphasis on the generation of a strategic "plan," a document mapping the long-term direction (both in terms of ends and means) of the organization. As such, it has a *product* orientation – the production of the plan is the primary purpose of the long-term direction setting effort. The primary focus of organizational and managerial activities then becomes the efficient implementation and control of crucial elements of the plan. The result of this mode is the development of five-year plans, for example, that are followed with but minor variation throughout the period covered by the plan. Planning is separate from other managerial tasks and can safely be delegated to staff functions because the process of developing the plan is viewed as a series of sequential and logical tasks. Planning is, thus, a distinctly different activity from the ongoing, day-to-day activities of managing the organization. Planning is usually viewed as a one-time, or at best, periodic activity.

Such an emphasis and focus is grounded in an implicit assumption of ultimate predictability and control. That is, the better the decision-maker is able to understand (and predict the effects of) the relationships and linkages between important and critical contingencies affecting organizational functioning, the better the ensuing plan and strategy. This assumption, in turn, implies a view of the external environment as relatively unchanging, stable and predictable. Further, the organizational system and the organizational environment are viewed as separate and fundamentally distinct entities or phenomenological levels of reality. Organizations, as cybernetic systems, can be controlled by manipulating internal arrangements based on the negative feedback loops that link organizational functioning to environmental requirements. Thus, an organization utilizing the planning mode generally has an internal orientation that focuses on adjusting system components based on negative feedback relating to attainment of organizational goals and activities. Underlying this mode are all of the implications and assumptions of Stage One systems thinking as described in Part II.

Because of these fundamental assumptions, organizations emphasizing the planning mode tend to be mechanistically structure and dominated by a reliance on 1^{st} order control mechanisms. Such organizations are characterized by a centralized structure of authority relationships and a high degree of formalization. Because of the cybernetic view of organizational dynamics, the characteristic learning mode is that of adaptive, single-loop learning. That is, learning efforts focus on more efficient implementation and control of the strategies and activities that best fit the operative environment, as mapped out in the strategic plan.

Strategic Management. The "management" mode, on the other hand, is much more oriented toward managing the *process*. The process through which strategies are developed is more significant to establishing and guiding the long-term direction for the organization than the plan itself. Thus, the primary focus of the management mode is on the setting of objectives and the formulation (or crafting) of strategies that are acknowledged to be subject to change and modification based on changing circumstances. Thus, rather that a one-time or periodic sequential activity, the management mode implies that the setting of long-term direction is an ongoing, continuous process. The criteria used to judge the successful direction setting is the effectiveness at managing the process of crafting, formulating and modifying the plan. Planning and management are, thus, not separate and distinct activities.

This emphasis on process, rather than product, is grounded in an open system view where the organization and environment (though distinct entities) are closely linked and continually interacting. Prediction (and, in turn, control) is possible in a probabilistic sense – thus, the need for contingency plans. The environment is predictable, in general terms. These assumptions, however, shorten the relevant planning horizon. Because of the relative degree of predictability, exploitation or adaptive learning is still emphasized but there is an element of exploration or knowledge generation in system development. Such organizations are less formalized, centralized and authoritarian. This view of social organization as open system is grounded in the assumptions and implication of Stage Two systems thinking as developed in Part II.

Strategic Learning. The "learning" mode characterizes the process of establishing the long-term direction for the organization in terms of strategies that *emerge* from continuous learning and a process of incremental adjustment and adaptation of existing functions and capabilities. Therefore, the characteristic learning mode is exploration – the generation of new configurations that are more efficient and effective in response to change. The primary focus for the management team in on providing a sense of purpose and direction (i.e., communication the strategic vision) so that organizational members, through their day-to-day activities, can enhance the organization's ability to respond to continual changes in both external and internal factors. Thus, the primary criteria for successful organizational functioning are its flexibility, adaptability and responsiveness. This perspective is grounded in a complex adaptive systems and Stage Three approach to systems thinking.

Organizations that emphasize a learning approach tend be more decentralized, participatory and to exhibit a lower degree of formalization. Such organizations rely more on 2nd and 3rd order control mechanisms because of the need to bring the informal control mechanisms (the interaction order) more closely in line with organizational goals and objectives. This is critical because the prediction and control of the long-term behaviors of the organizational system in inherently unpredictable – each element (i.e., member of the organization) must contribute to the overall flexibility, adaptability and responsiveness of the system. To accomplish this, control must be decentralized.

In practice, elements each of the mode are a factor in a determination of the method by which any particular organization is directed. In keeping with the general theme of this research effort, the above discussion is not a case of arguing that one mode is "best" or that one is most appropriate. Rather, the argument suggests that implicit and fundamental views on the dynamics processes of system will determine which elements of the modes are emphasized in any specific organization.

Modeling Complex Systems

Though the primary purpose and emphasis of this project is on conceptual and analytical integration, a few brief comments on the implications for empirical modeling are warranted. A complex systems perspective suggests that the understanding of organizational and social system dynamics can be developed only by incorporating and appreciating multiple levels and the hierarchical structuring of phenomena, positive feedback effects, nonlinear relationships between components, and nonequilibrium concepts. A failure to incorporate such elements precludes any meaningful explanation, or discovery, of the laws and rules governing social behaviors. From a complexity perspective, reductionist models – those incorporating some subset of phenomena at one level of analysis only -- when coupled with an emphasis on the effects of negative feedback, linear methods and equilibrium-based assumptions are inherently limited. Such models and methods are, by their very nature, unable to describe adequately the temporalities of complex phenomena.

How then should the general implications of the complexity sciences, and the proposed connectionist model, be examined empirically? What methods and methodologies can be used to test those implications and exhibit the models usefulness. Puccia and Levins (1985) note that an ideal model of system behaviors would simultaneously meet three criteria:

1) The model would maximize generality (or generalizability) allowing for extension of the model's results and implications to other (similar) situations (i.e., it would exhibit external validity).
2) The model would be precise and quantifiable, allowing for accuracy in measurement and control of significant factors.
3) The model would be realistic in terms of its situational context.

To the extent that any empirical model meets these three criteria, it approaches the goals of explaining and understanding. Having met the three criteria, the implications of the model may prove useful at the applied level for modifying system behaviors.

However, "...it seems to be a fundamental principle of modeling that *no model can be general, precise, and realistic*" at the same time (Puccia and

Levins, 1985: 9). Any particular model tends to place emphasis on one of the criteria and can meet, at best, only two of the three. Thus, the researcher must determine which of the criteria to emphasize and/or to sacrifice. This results in three basic modeling strategies:

- *Generalizability* can be sacrificed for *realism* and *precision*. This strategy would result in models with high precision and realism *for a particular system*, but which may have little validity or relevance outside of the context for which it was developed;
- *Realism* can be sacrificed for *generalizability* and *precision*. A modeling strategy sacrificing realism would result in very general models which, while precise and externally valid, would require such simplifying assumptions and control of parameters that small deviations from those unrealistic assumptions destroy all semblance to the real system of interest; or
- *Precision* can be sacrificed for *generalizability* and *realism*. This strategy gives up quantifiability and precision (i.e., quantitative predictive) for a focus on a description of the qualitative behaviors of the system of interest.

These criteria can be related to three generic types of empirical strategies and methodologies: quantitative methods, qualitative methods and simulation methods. Each of these has distinct characteristics, strengths and limitations

(Table 8.3).[8] The trade-off in meeting these criteria is most apparent in the difference between quantitative modeling techniques and qualitative approaches.

Quantitative Methods

Quantitative methods emphasize precision of measurement and quantifiability of concepts, constructs and proxies. From a nomothetic and quantitative research perspective, this criterion cannot be sacrificed. Thus, the trade-off is between generalizability and realism. In most cases, realism is abandoned in the interests of simplifying complex reality, dominated by the need for precision and a requirement that the results be generalizable to similar domains. Precision and generalizability result to the extent that the techniques and models exhibit construct validity (the proxies chosen for measurement actually reflect the underlying constructs of interest) and external validity (the model is representative of general processes in operation). However, these advantages may be outweighed by a lack of realism. Simplifying assumptions, data limitations, and an inherent reductionism limit the potential for such models to reflect and capture the subtleties and complexities of social phenomena. This is particularly true when efforts are made to quantify the cognitive and subjective feature of social behaviors. At the extreme, this leads to a position of

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[8]The typology in Table 8.3 represents, obviously, a broad general generalization of the implications of each of the methodological approaches. Any *specific* methodology would have to be assessed on its own terms with respect to generalizability, realism and precision.

operationalism and the assumption that if it cannot be quantified, the phenomenon is not relevant.

However, researchers are attempting to incorporate the implications of the complexity sciences (most notably chaos and catastrophe theories) into quantitative models (Brown, 1995; Morrison, 1991; Butler, 1990; Kaplan and Glass, 1995). For example, Morrison (1991) develops a typology of the relationship between mathematical techniques and strategies used to model system behaviors. The typology (the "Hierarchy of Dynamic Systems") can be applied to either models or the data incorporated into those models (Table 8.4).[9]

A *Type Zero* model has no dynamics, strictly speaking. Its state remains unchanged. Models of *Type I* are comprised of solvable systems. Models of these systems are composed of a set of (usually linear) differential equations that have exact solutions. *Type II* represents models of problems that can be solved by perturbation techniques. In practice, this means that useful approximate solutions can be constructed by limit processes involving 'small' parameter changes. *Type III* systems have chaotic solutions. A typical trajectory may seem to be behaving normally and then executes a sudden change of course. Some examples have irregular cycles that may disappear for

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[9]Alternate typologies are proposed by Brown (1995: 2-5) and Butler (1990: 38-40). Brown's typology, following suggestions by May (1974), focuses specifically on models which include a time, or temporal, dimension. The categories of Brown's typology are deterministic continuous time models (Model I), deterministic discrete models (Model II), probabilistic continuous models (Model III), probabilistic discrete models (Model IV), and models with randomly fluctuating parameters (Model V). Butler's typology includes static linear, static nonlinear, dynamic linear, dynamic nonlinear, and includes a distinction between discrete and continuous time dynamic models.

a while and then return. This is the most difficult type of system to model, since there are no apparent regularities. *Type IV* systems are 'random.' A roulette wheel is a good one-dimensional example.

Chaotic systems (Type III) comprise the transition between solvable and near-solvable systems and those that are completely stochastic or random – a bridge between deterministic and stochastic systems. They are the most recent to be investigated by scientists and mathematicians because, historically, they are the least susceptible to study using the traditional tools of mathematical analysis.[10] In fact, until the 1970s, the scientific community largely ignored phenomena that did not fit either Type I or Type II systems (Morrison, 1991). Traditionally, natural and social scientists assumed that it was acceptable to use linear approximations (Newtonian), modified by "error" terms, to describe nonlinear relationships, given that nonlinear relationships are notoriously difficult to handle. This has the essential effect of forcing descriptions of Type III systems (and models) into Type I or Type II. Unfortunately, chaos and catastrophe theories suggest that even the tiniest error or 'noise' in the system can balloon into huge consequences.

[10]See Chapter 4.

Qualitative Methods[11]

Qualitative and ideographic methods emphasize the reality criterion and are the methods of choice by researchers in the subjectivist "camp."[12] Ideographic methods focus on explanations of how the particular contextual, situational and historical factors contribute to and/or serve as constraints on social behaviors. A principle effort is on capturing those subjective elements that resist attempts at quantification. This emphasis on capturing the reality of the subject of the research project in its holistic totality suggests a trade-off, from a qualitative research perspective, between generalizability and precision – with generalizability most often sacrificed. The resulting descriptions of observed behaviors might capture the "reality" of social existence with great precision. The descriptions and accounts offered for these phenomena are often precise and well defined – though not necessarily highly quantified. However, because of the primary focus on contextual, subjective and semiotic concerns, ideographic studies are of criticized as examples of *reportage*, and not true scientific (i.e., quantitative) research.

Simulation Methods

Simulation techniques attempt, in a sense, to bridge the gap between quantitative and qualitative strategies and, thus, different simulation modeling

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[11]For a rationale and discussion of qualitative research (including ideographic and ethnographic methodologies) see Spradley (1979), Lofland and Lofland (1984), Sharrock and Anderson (1986), Strauss (1987), and/or Strauss and Corbin (1990).
[12]See Chapter 6.

techniques emphasize different criterion (Ragin, 1987). For example, the simulation model develop to examine chaotic processes in innovated search dynamics (Koput, 1997) is highly quantified and precise (quantitative simulation techniques). Even in this case, Koput (1997) notes that:

> The goal of any mathematical model in behavioral research is to help understand qualitative aspects of the behavior under study (Koput, 1997: 537).

Simulations techniques, such as the loop-analysis techniques developed by Puccia and Levins (1985) represent qualitative simulation techniques, where the goals of quantification and numerical prediction are almost completely abandoned. Quantitative approaches have, and will continue, to be useful in many areas. However, when dealing with social phenomena, qualitative simulation techniques appear to have the most promise (at least in the near future) for examination of the connectionist model of organizational dynamics.

Several reasons suggest this conclusion. First, social behaviors cannot be experimentally controlled (as with physical phenomena studies in a laboratory setting). Second, in social settings conflicting interests are nearly always present. Third, many of the more important constructs and variables are either nonquantifiable (except with proxies of questionable value) or change in value with any attempt at measurement. Fourth, in a complex system of only a modest number of elements and interconnections, any attempt to specify the system completely and measure the magnitude and interactions of all the linkages in combination would be well beyond practicality. Fifth, attempts at quantification of connections or the establishment of accurate baseline measures ignores the implication that the essence of social dynamics lies in the rules of construction (i.e., in the cognitive schema of members) of the system and not in absolute values. These considerations suggests that the most appropriate method of attempting to extend the connectionist model developed in this project is most likely through some form of qualitative modeling technique in order to develop general and realistic empirical models of social dynamics.

The complexity sciences suggest that an inclusion of hierarchy, positive feedback, nonlinearities and disequilibria imply theoretical limits to precision, quantifiability and quantitative prediction. This is a primary reason for reliance on the analytic and deductive strategy employed in this project. It may be that qualitative results are the best that social researcher can realistically hope to attain. Thus, the argument that "sacrificing" precise and quantitative results does not mean that the development and formulation of general and realistic models are irrelevant to social researchers.

Through training and socialization, social science researchers implicitly assume that individuals and organizations function in a deterministic (or at least, probabilistic with an underlying determinism) universe. The task for researchers is to discover the deterministic and nomothetic structure that accounts for change, developmental and transformational processes. Attendant to the discovery of these laws is a measure of predictability and the ability to control organizational outcomes. At the same time, many wish to reserve a measure of free-will and choice for individuals – that individuals can, and do, make a difference. Efforts to resolve this dichotomy have proven problematic. The complexity sciences, and the connectionist model developed in this project, offer a potential for resolution. The implications of this research effort suggests that *both* free-will and determinism have a place in theoretical arguments and that researchers need not be forced into an *either/or* paradigmatic approach to the explanation and understanding of social realities.

Concluding Remarks and Future Directions

As a final note, the position taken at the beginning of this project should be reiterated. Empirical work (observation and measurement of objective "reality") is necessary and important for scientific progress to occur. Some may even argue that empirical efforts are the central means of scientific inquiry and the scientific method. However, theoretical guidance is necessary to help in determining which aspects of reality to observe and measure. "Reality" is complicated, complex and multidimensional. Without theoretical guidance, researchers are reduced to "data dredging," raw empiricism and atheoretical research programs. These two aspects of scientific inquiry (theory development and theory testing) – though conceptually separate and distinct tasks – are both necessary for scientific progress. They are complementary tasks.

Though no test of hypotheses or summarization of the empirical literature is presented here, the variables, models and propositions of this conceptual and theoretical work should serve to stimulate empirical efforts. In this regard, five areas warrant further investigation.

1. Are the proposed elements of the multidimensional connection supported? Can the view of connections consisting of modes of interaction and types of flows be supported? These questions appear amenable to empirical investigation from a complexity science perspective.
2. Can the proposed link between specific patterns and configuration of connections, system control parameters and resulting behaviors be demonstrated? This question can be addressed through further efforts to simulate the dynamics of complex systems.
3. Can the proposition the rates of flow form the primary linking mechanism between holons (e.g., between the system and its environment)? This question requires further theoretical development.
4. Can the proposed link between control mechanisms (formal and informal) be demonstrated? That is, can it be shown that manipulation of control mechanisms have an effect on the patterning and configuration of connections that defines the system's deep structure? Simulation methods appear to hold the most promise for addressing this question.
5. Can the proposed link between cognitive structuring and subjective interpretation and manipulation of system control mechanisms be

demonstrated? Qualitative research methodologies may provide insight into this issue.

Thus, it seems evident that a variety of methods and methodologies are appropriate for exploring the issues and questions raised by this research effort. This should not be a surprising conclusion. Social systems are complex and multidimensional entities. Explanation and understanding of the complex dynamics of such complex and multidimensional systems require multiple methods and methodologies. Again, it is not a question of using either quantitative or qualitative (or simulation) methods. It is, rather, a question of how both (or all) of these methodologies can best be utilized in furthering our understanding and explanation of the developmental and transformational change processes in social organization.

The central argument, and primary conclusion, reached in this project is that the complexity sciences – as exemplified by a CAS connectionist approach – offers a paradigm that promises to move the social and organizational sciences beyond "either/or" argumentation. The fundamental contribution of the research effort is that it provides an approach that integrates and incorporates *both* subjective and objective elements *and* macro and micro level phenomena in the explanation of the dynamic processes and mechanisms of organizational development and transformation (Figure 8.3).

APPENDIX A

TURNER'S DYNAMIC THEORY

OF SOCIAL INTERACTION

INTRODUCTION

Turner (1988) develops a dynamic model of the processes of dyadic social interaction following the general analytical strategy for theory development (Turner, 1986) guiding this project. A description of this theory is important in that it provides the necessary foundation for the CAS connectionist model of dynamic organizational processes developed in Chapter 7. A crucial element of the connectionist model is that the mode of exchange (either RES of GES) provides the primary informal control mechanism linking micro-level level dyadic interactions to the deep structure of organizational connections and macro-level organizational dynamic processes. As such, a theory explaining the underlying processes of social interactional processes is fundamental to the argument.

Social interaction is defined as "...a situation where the behaviors of one actor are consciously reorganized by, and influence the behavior of, another actor" (Turner, 1988: 14). Overt individual behaviors and covert cognitive processes are the domain of psychology. The term *individual behavior* broadly includes an individual's overt actions in time and space (behaviorism), the covert and internal deliberations of individuals (cognitive psychology), and the physiological processes of individuals (neuropsychology). When these individual behaviors and processes come into contact with others, the resulting interaction provides the basis for "social" activity – thus social interaction is the basic unit of sociological analysis. Turner's theory links individual level (psychologically based) phenomena to social phenomena (the dyadic interaction). The connectionist model developed in Chapter 7 extends Turner's analysis to link these dyadic micro-level social phenomena to macro-level organizational phenomena (the province of organizational theory). This is accomplished by integrating the complexity science perspective of CAS into social theory.

A Dynamic Theory of Social Interaction

Three processes constitute social interaction: motivational processes, interactional processes, and structuring processes (Figure 7.1). However, though interrelated, each process is conceptually separate and distinct. *Motivational processes* explain how (to varying degrees and in diverse ways) individuals are energized and mobilized in their interactions with others – i.e., what provides the impetus for interaction. *Interactional processes* denote what people actually do when they influence each other's behavior – what actually occurs during the interaction. *Structuring processes* are concerned with how social interactions are repeated across time and organized in physical space – how can the consistency, or lack thereof, of interaction be explained.

Each constituent process requires separate and distinct models and principles to explain the mechanisms involved. None of the processes, considered separately, adequately explains the interaction process; neither can any one of the processes be conceptualized solely in terms of the other. Each is distinct, but combined, they offer an explanation of the operative dynamics of social interaction. The manner in which people signal and interpret (interactional processes) is closely related to the motivational energies of the individuals involved in the interaction. In turn, motivation is circumscribed by prevailing structural arrangements as well as by the actual mechanisms of the signaling and interpreting activities. Moreover, the structure of an interaction is very much affected by the motivations of the individuals involved as affected by the signaling and interpreting activities. The point of decomposing the interaction process into its constituent processes (and developing separate models and propositions for each) is to examine the causal influences of each process on the others.

Turner's analysis focuses on the *dyadic* interaction. *The extension proposed by the connectionist model is that the joint effect of many recurring dyadic interactions in an organizational setting results in the emergence of a dominant mode of exchange. This mode of exchange provides the primary informal control mechanism linking micro-level dyadic processes to macro-level organizational processes. This occurs through the effects of the mode of exchange on the deep structure of connections that define the organizational system*. Thus the purpose of this Appendix is to utilize the analytical model of dyadic social interaction processes as a "jumping off" point for the integration of the complexity approach into an analysis of organizational developmental and transformational change processes.

What follows is a description of each element in Turner's synthesized model. For the first two elements (motivational and interactional processes), the ideas are presented graphically but the propositions developed by Turner for each process are not developed. However, when the final element (structuring processes) is described, propositions are included. Table A.1 lists the propositions relevant to the purpose pursued in this analysis. This is appropriate because, in a large sense, these structuring processes provide the fundamental micro-theoretical foundations for the connectionist model of organizational dynamics presented in Chapter 7.

As such, this appendix is essentially a paraphrasing and summarization of the complete argument Turner presents in A Theory of Social Interaction (1988). It should be noted that what follows is *Turner's interpretation* of the various theoretical approaches underlying the dynamic model of dyadic interaction, not *necessarily* the views of the originators of the approaches. Turner is, of necessity, selective in that he chooses to extract those elements of each approach that he deems most relevant to explaining each element of the processes of social interaction.

Motivational Processes

Turner's bases the synthesized analytical model of motivation on an analysis of utilitarian, behaviorist and exchange models of motivation.[1]

Foundations

Utilitarian approach. In utilitarian explanations of motivation, actors are rational in that they weigh and assess alternative lines of conduct in terms of costs/benefits and expected payoffs, or "utilities." Utilitarian models are cybernetic in that two types of feedback loops are included (Figure A.1). First, the principle of "marginal utility" alters the value structure of the individual such that the more a particular utility is received, the less valuable it becomes – its rank ordering in an individual's preference structure is lowered (negative feedback to the hierarchy of values). Second, there is an assessment (1) of the gain or loss for each act is incorporated into rational calculations for future acts and (2) of the probability of receiving a given utility based on past experiences and/or access to relevant information affecting that probability (negative feedback). Thus, action is motivated by the pursuit of "pleasure" as measured by utilities. Action, from the utilitarian perspective, is a function of four interrelated forces: the individual's hierarchy of values, adjustments in these

[1]Turner also analyzes Simmel's early exchange model, Mead's social behaviorism approach, Durkheim's social solidarity model, and the Freudian psychoanalytic approach in his survey of early approaches to explaining motivational processes. However, the three discussed here are the primary foundation for his synthesized model of motivational processes.

hierarchies by marginal utility, past experience in receiving profit or loss, and access to relevant information about probabilities of receiving varying utilities for different courses of action.

The utilitarian approach is well known and provides the basis for many of the rational models of organizational behavior. However, critics of the utilitarianism note that models based on the perspective "...tend to be asocial in that other actors are not present, or, when they are inserted into the model, they are part of an amorphous and competitive marketplace" (Turner, 1998: 25). Thus, it has very little to say in terms of interaction processes – it may offer an account for *action*, but not for *interaction*. Additionally, individuals may not in actuality have a hierarchy of value preferences that is well-ordered or structured. Further, calculations by individuals may not be "rational" in the sense that values are not clear-cut, relevant information is not complete and past experiences may be difficult to remember or to apply to new situations.

Behaviorist Approach. The behaviorist approach to motivation is similar to utilitarianism in that actors seek to obtain rewards and gratification (utilities) and avoid punishments (costs). However, most behaviorist models abandon the utilitarian emphasis on rational calculation; in the extreme behaviorism of Skinner and Watson, internal processes are completely disregarded and reliance placed solely on observable responses to external stimuli (Figure A.2). However, even in its extreme form, behaviorism implies some ranking or hierarchy of values (needs) in terms of imposed deprivations of valued rewards. In the final analysis

> ...while the behaviorists did not explicitly introduce the process of calculation into their models, the other elements of those models are virtually the same as those in utilitarianism formulations...Instead of utilities, behaviorism stresses gratifications or punishments; rather than marginal utility, behaviorism refers to satiation; as an alternative to calculations of costs and profits, behaviorism analyzes conditioned responses and extinction; and instead of utilitarian concerns over hierarchies of value, behaviorism introduces inferences about the salience of needs (as determined by levels of deprivation) (Turner, 1988: 27).

Thus all the criticisms of the utilitarian approach apply to behaviorism, with the addition that behaviorism (at least in its extreme form) totally disregards complex cognitive processes – the most human component of behavior. Most importantly, however, both utilitarianism and behaviorism focus on the individual actions, not social interactions. With an incorporation of exchange-theoretic concepts, however, motivation becomes a truly social phenomenon.

Exchange-Theoretic Approach. Social exchange theories address the major shortcoming of both behaviorism and utilitarianism by "socializing" motivation. The exchange-theoretic approach incorporates many elements from utilitarianism and behaviorism (assessments of rewards/gratifications in terms of actor's values/preferences). However, it provides an explanation of what drives people to interact by stressing that individuals, at least in large part, must obtain these rewards and gratifications from other individuals (Figure A.3). These valued rewards (including rewards such as power, prestige and approval) are obtained only through negotiation with others and an expenditure of resources. Unlike the utilitarian approach, there is no presumption in exchange theories that actors seek to maximize rewards – it is only assumed that *some* profit is desired. Further, it is not assumed that calculations are *necessarily* either rational or logical – they are often implicit and/or constrained by external cultural and social forces. Because of these constraints and because of the distortions inherent in the negotiation process, actors rarely have complete information about alternatives. The point is, however, that interaction is motivated by *interpersonal negotiations* over what resources must be given up to obtain valued resources from others. Actors' implicit and explicit preferences and structure of reward value inform these negotiations.

These three approaches provide the basis, in varying degrees, for most contemporary theories of motivation. Modern interactionist theory, building on Mead's (1962) early work, focuses on the exchange of symbolic rewards to sustain a sense of self. Giddens' (1984) psychoanalytic model emphasizes the subconscious needs and anxieties that motivate exchanges between individuals. Ethnomethodological models focus on the value of social interaction in developing, maintaining and sustaining a sense of shared understanding, facticity and intersubjectivity. Elements of these contemporary approaches are incorporated in a synthesized model of motivation.

Turner's Synthesis

Turner's synthesized model of motivational processes is depicted in Figure A.4 where motivation to engage in interactions with others is a dynamic process among interrelated elements. It does not represent "...a general theory of motivation per se, only a model of motivation *during interaction*" (Turner, 1988: 58). The elements of the motivational model mutually influence each other and unfold over time. Thus, the dynamic process is characterized by feedback loops that alter or sustain, constrain or enhance the direction of the motivational impulse. It is not simply a linear, sequential feedback system. Multiple causal processes are at play, many of which operate simultaneously and in parallel. Additionally, though the process is at times explicit and conscious, much of the process is implicit and unconscious. Conscious attention to the motivational process by an individual is highly selective – many of the needs, values and desires (which can be satisfied only through exchanges with others) that motivate individuals to interact operate subconsciously and tacitly.

The variables on the far left of the model operate at the most subconscious level; from left to right, the processes become increasingly conscious. The three basic needs on the far left – "group inclusion," "trust," and "ontological security" – are "...unconscious in the sense that most individuals are unaware of their operation during interaction until one or more of these fundamental sources of deprivation is not adequately met" (Turner, 1988: 59).

The "need for a sense of group inclusion" is the potential deprivation associated with a failure to feel "involved in" and "part of" ongoing social activity, and is based on concepts derived from Durkheim (1912), Mead (1934) and Collins (1975,1986).[2] The "need for a sense of trust" derives from Giddens' (1984) structuration theory and influences the "...degree to which an actor has interpersonal trust or the implicit belief that others are predictable and reliable" (Turner, 1988: 60). Structuration theory (Giddens, 1984) also suggests the third variable, the "need for ontological security." This refers to the notion that individuals have a need for a sense that "things are as they appear." Individuals need to feel that they understand and are able to interpret a particular situation – that the purpose of the interaction is known and that appropriate ways to act in a particular situation are implicitly adhered to by all parties to the interaction. These needs are unconscious and are not salient unless they are not met. Then, a sense of needs deprivation results in an increased level of diffuse anxiety.

Anxiety, or a generalized and unspecified sense of diffuse discomfort and of being "at odds" with one's surroundings, results when one of these needs remain unmet (in addition to the "need to sustain self" to be outlined shortly). Anxiety[3] is a "...mediating emotional state between less conscious needs for inclusion, trust, and security and the increasingly conscious motives

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[2]See Turner (1988) for citations.

[3]Turner's conceptualization of anxiety is based on Simmel and Mead.

on the right side of the model" (Turner, 1988: 61). If this "need to avoid a diffuse sense of anxiety" is not met it becomes an important source of motivation to engage in interactions with others in order to satisfy the deprivation "caused" by lack of security, trust or sense of inclusion. Thus, a high level of *diffuse anxiety motivates individuals to restructure existing interactions*, or *to seek new interaction opportunities*, to satisfy the deprivations. Behavioral responses to diffuse anxiety are variable and are circumscribed by other variables in the model, and by the feedback loops, but will

> ...cycle around efforts to deal with the anxiety associated with these three needs. Furthermore, because these needs tend to remain unarticulated, creating nonspecific anxiety, individuals often have great difficulty pinpointing the source of their disequilibrium, with the result that considerable interpersonal energy can be devoted to meeting those needs as individuals grope around for a solution to their often vague feelings of discomfort (Turner, 1988: 61).

Variable responses to reducing the degree of diffuse anxiety include engaging in interactions that will (1) satisfy a need to sustain self-conception, (2) satisfy symbolic and material needs, and (3) increase a sense of "facticity." Engaging in such interactions require a mobilization of energy (i.e., individuals become "motivated"). The energy thus mobilized is used in sending signals to others (signifying a willingness to enter into an exchange interaction) and in interpreting and understanding the signals of others.

The need to sustain a self-conception suggests that individuals seek to "feel good" or have a positive image of themselves. An increase in feelings of diffuse anxiety will increase the need for sustaining self-conception (i.e., increased anxiety leads to lowered conception of self). The lowered self-image may be mitigated by seeking to engage in types or classes of interaction situations that will have a positive effect on a view of one's self. This causal linkage is bi-directional in that image of self feeds back to either reduce or increase the level of experienced anxiety, depending on the success of the interaction.[4]

Interactions designed to meet needs for symbolic and material gratification operate simultaneously with efforts to maintain and sustain self. The actual symbolic and material "rewards" that serve to satisfy these needs are situational and context specific to the particular interaction. Authority and power interactions, for example, imply a set of symbols and materials (e.g., the right to give orders, to control space, to demand deference, to make money, etc.) that are completely different from the expectations inherent in an affective interaction (e.g., respect, love, companionship, etc). There is a utilitarian (though not necessarily rational) aspect of cost/benefit analysis to the interactions where such symbolic and material rewards are exchanged. Either consciously or unconsciously, the costs/penalties are compared to expected gains from the exchange interaction. If the ratio of costs to benefits – if the energy expenditure required to obtain the symbolic and material rewards is less

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[4]The dynamics of sustaining self are complicated, complex and involved a number of unresolved issues (e.g., the "core self" versus the "peripheral self"). The issues involved in this are beyond the scope of our discussion. This issue is a point of intersection between psychology and sociology. Our purpose here is to provide the foundations for a social and organizational level theory. Interested readers should refer to Turner (1988) for discussion pertaining to the dynamics of sustaining and maintaining self-image.

than the energy gained – is satisfactory, the exchange interaction will occur. Even if the exchange is not consummated, a certain amount of energy must be expended in searching out opportunities and signaling a willingness, or need, for interaction. The important point here is that a heightened sense of anxiety motivates individuals to seek interactions where the symbolic and material rewards obtained in exchanges with others serve to reduce that anxiety. These rewards must have salience (i.e., they are perceived as anxiety reducers) and must be available at a reasonable "cost." The individual is motivated to interact with other individuals in order to enter an exchange relationship – if the "rewards" are not available through existing and ongoing relationships, the individual is motivated to seek new interaction opportunities.

Heightened anxiety can also serve to increase a need for a sense of "facticity." This refers to a need for a sense of a shared and factual world – an individual's need to feel that his/her implicit "account" of what is real and important is shared by others around the individual.[5] This sense of facticity feeds back to sustain a sense of ontological security (i.e., the "knowledge" of what is "real"). If absent or insufficient, it leads to an expenditure of energy to engage in interactions that can enhance the sense of shared understanding.

In summary, Turner (1988) grounds his conceptualization of the *motivation* to engage in interactions with others on the principle of needs deprivation. Unfulfilled or unsatisfied needs (primarily at a subconscious level)

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[5]Turner's conception of "facticity" relies heavily on Garfinkel and the use of ethnomethods by individuals to construct – and agree upon – the reality around them.

lead to diffuse feelings of anxiety. Such anxiety motivates the individual to seek interactions leading to symbolic or material rewards and that sustain (a positive) self-conception and maintain a sense of shared facticity with others. The mechanisms to satisfy more conscious secondary needs are *only* available from others, through interactions that lead to exchanges between the individuals. Seeking and maintaining these interactional exchanges require a mobilization of energy in order to signal and interpret with others. Thus, the model offers a hypothesized set of relationships that explain the motivation to engage in interaction with others.[6] However, it does not explain what occurs during the *act* of interacting. Unsatisfied needs (of various types and levels) motivate individuals to signal their willingness to engage in interaction with others. Once the motivation to signal others has occurred – and signals sent, received and interpreted – an entirely separate set of processes are needed to explain the interactional processes.

Interactional Processes

Motivational processes explain only what energizes or motivates behavior during the course of interaction (*why* individuals interact), but not *how* motivated individuals respond to others during the interaction – the "mechanics of interaction" or what individuals actually do when they influence each other's behaviors. Interactional processes revolve around individuals' capacity to

[6]Turner discusses each of the paths depicted in Figure A.4. Such a discussion is beyond the scope of the overview presented here.

signal a course of behavior with gestures, to interpret each other's gestures, and to adjust their responses to those interpretations. Grounded in the symbolic interactionist perspective of Mead and the phenomenological approach of Schutz – the "conceptual core" for all modern theorizing on interactional processes – the processes of mutually signaling and interpreting are proposed as the vehicle by which actors influence each others' responses. Unless signals are mutually interpreted and utilized in subsequent signaling, interaction does not occur. Thus, a theoretical analysis of interaction must explain the dynamics of signaling and interpreting of gestures. Turner synthesizes role theory, dramaturgical analysis, ethnomethodology, and elements of critical theory in constructing an integrative theoretical explanation of these dynamics.

Foundations

Turner's Role-Taking and Role-Making. Turner's[7] role-theory perspective combines symbolic interactionism with role theory to emphasize "role-taking" and "role-making" as integral components of the signaling—interpreting—responding processes as key to explanations of the interaction process. *Role-taking* refers to the process by which individuals read and interpret the gestures of others and make assumptions of the other's perspective, disposition and likely action based on the belief that the other's

[7]The Turner here is Ralph, not Jonathan.

behavior is organized into identifiable roles. These roles are in essence a system of signals emitted by the "other" that are assumed to be consistent and involve stereotypical sequences of behavior that are part of the knowledge base of competent actors. Roles (i.e., the system of signals signifying a certain expected behavior) are culturally conditioned through socialization processes and experience and are assumed to be consistent unless, and until, otherwise demonstrated.

In an interaction episode, individuals "run through" their (cognitive) inventory of role conceptions in order to make sense of the behavior of others. An assessment and determination of what the gestures and behaviors of others signal is used to make preliminary imputations as to the meaning of the other's observed behavior. Thus, individuals make an initial interpretation of the gestures and behaviors of others based on identifiable role-conceptions that are assumed consistent.

Conversely, in "role-making" individuals consciously and unconsciously organize their own signals in order to make, or assert, a role for themselves in interactional episodes. The same cultural frameworks, norms of consistency, and inventory of role-conceptualizations that are used to interpret the actions of others in role-taking are used in role-making. Like role-taking, role-making is situation dependent. The particular role being made for one's self is influenced by the conception of self as a certain kind of individual deserving of certain responses from others in a certain surrounding, situation or set of circumstances. In doing so, individuals orchestrate the signals to assert a role selected from the stock of role-conceptions deemed appropriate to the particular situation. This role-taking and role-making aspect of signaling and interpreting, of course, depends on a shared (intersubjective) inventory of role conceptions (Figure A.5).

Turner's notions of role-taking and role-making are central and complementary dynamics in the interpreting and signaling process. However, Turner's framework offers no explanation of how these roles and role expectations become routinized and part of the individual's inventory of role-conceptions. Goffman's analysis of rituals, frames and stages provides some insight into these processes.

<u>Goffman's Dramaturgical Analysis</u>. The major contribution of Goffman's approach is recognition that rituals permeate every aspect of daily life and serve to reinforce social structural arrangements and the individual's inventory of role-conceptions. A major component in the process of signaling to others involves ritualized behaviors and responses – stereotyped sequences of gestures – that elicit stereotypical behaviors and responses from others. In doing so

> ...actors affirm their mutual involvement in, as well as dictate the sequencing of, the interaction. Such rituals mark interaction at critical junctures, particularly openings and closings, but also at crucial turning points in between. In this way, the flow of an interaction is greatly facilitated, allowing people to enter, proceed, and exit unambiguously (Turner, 1988: 92).

This view of ritualized behaviors is complementary with Turner's conceptions of role-making and role-taking – rituals can be viewed as important in efforts at role-making and at interpreting the roles that others are attempting to make for themselves.

Particular rituals are appropriate for specific types of interaction situations and are a part of an individual's cultural orientation. As rituals are used appropriately, interaction is facilitated and the cultural orientation of the actors (and the macrostructural arrangements that create the situations) are reinforced. Upon entering an interaction episode, individuals engage in ritualized behaviors (ritual-make) that involve signaling, interpreting and responding to gestures. Any particular interaction episode is "framed" such that the episode is delimited and bounded as to what is appropriate and acceptable and, conversely, what is inappropriate and unacceptable – what should and should not occur during the interaction. These *frames of reference* are not so tightly structured and restricting because individuals' cognitive and deliberative capacities

> ...allow them to shift frames rather easily, broadening, narrowing, or even changing their substantive content. To some degree rituals are the vehicle by which this occurs, but rituals that actually signai movement to a new from are often very subtle. This facility for framing and reframing interaction allows for interpersonal flexibility and, at the same time, circumscribes the range of <acceptable> responses (Turner, 1988: 93).

Like rituals, individuals possess stores of frames, knowledge about the procedures for shifting frames, and understanding about the contexts in which varying frames and their transformations are appropriate.

In addition to rituals, and the frames that assist in a determination as to the appropriate ritual to perform, actors utilize physical "props" in an interaction to reinforce the ritualized behavior. In some instances, the prop may itself be a signal as with varying the proximity (the physical distance) between themselves and the other. Goffman's early work, especially, emphasized this physical staging of the interaction and argued that the interaction process is like a staged play that provides a backdrop to the "performance" of exchange – hence, dramaturgical analysis. Interaction, as the performance of a scripted role, often revolves around "...people's use of relative positioning of bodies, movement back and forth between 'backstage' and 'frontstage' regions, and employment of physical props to signal a course of action" (Turner, 1988: 93). Of course, such a dramaturgical exercise ("stage-making") operates both ways – it gives an indication of what to expect from an individual and what is, in return, expected in a particular "performance."

Macrostructural parameters (i.e., existing social structures and the resulting appropriate methods of interaction) reside in the "collective conscience" of the members of society. These parameters determine the degree of shared cultural orientation as to the appropriate frames, rituals, and stagecraft in any particular interaction episode. In an encounter, actors interpret their own gestures and signals – and those of others – by "ritual-taking," "frame-making," and "stage-taking." The interpretation of the signal sent by others is grounded in the cultural orientation of the participating actors –

a deliberation of what is appropriate behavior (rituals, frames and stages), given the particular circumstances surrounding the interaction. Additionally, a conception of self is an important factor in the deliberation as to appropriate rituals, frames and stages available for use by the individual in choosing signaling behaviors from the inventory of all possible behaviors. To the extent that the interaction is "successful" (i.e., a shared understanding develops), the deliberations and conceptions of self that went into the choice of rituals, frames, and stages are reinforced. To the extent that these deliberations are reinforced, they reinforce the shared cultural orientations of the parties to the interaction; in turn, these reinforced cultural orientations reinforce the macrostructural parameters and existing structure of social relations and interactions (Figure A.6).

Goffman's dramaturgical approach made three important contributions to an understanding of the interaction process. First,

> ...<h>is work was the first to recognize that everyday life is punctuated with rituals that mark group membership and that structure is the sequencing of everyday interaction. Second, his earlier works were instrumental in conceptualizing the ecology and geography of interactions as crucial signaling processes. And third...<he> transformed rather static notions like "definitions of the situation" into a more active process of framing and reframing interaction settings (Turner, 1988: 95).

<u>Garfinkel's Ethnomethods</u>. Garfinkel's phenomenological approach makes the claim that what traditional sociologists study does not really exist (i.e., that there is no objective "reality," that the only "real" social phenomena

those that are subjectively experienced). This claim has relegated much of this extreme form of ethnomethodology to the status of a "kind of cult fringe" within sociology (Turner, 1988: 95). However, several insights derived from his work enhance an understanding of interaction processes. Particularly, the process of "accounting" is central to the understanding of the signaling and interpreting dynamics in ethnomethodological analyses of human interaction. Individuals enter into interactions with certain stocks of knowledge about the context of the interaction. These stocks of knowledge are tacit understandings about the social world that can be invoked and combined though cognitive deliberation. An important component of these stocks of knowledge are *stores of ethnomethods* which create, sustain, or repair a sense of "facticity," or offer an account of what is real, in the world around us. Ethnomethods provide structure for the *stocks of knowledge* used in the gesturing/signaling procedures employed by actors. Stocks of knowledge represent the content or components available for use; stores of ethnomethods (i.e., "folk methods") provide for the ways these components can be utilized (Figure A.7).

The principle mechanism through which stocks of knowledge and stores of ethnomethods are used to make an "account" of reality is talk and language. Language allows individuals to "sign objects," or designate what exists in an environment ("account-making") and, when accompanied by ethnomethods, to convince others to accept the account produced by language use. Thus, an actor's account of reality influences the accounts made by others. Others' accounts are responded to (i.e., interpreted) by the actor ("account-taking") using general stocks of knowledge and stores of ethnomethods. Two important processes are involved in this account-taking process: 'indexicality" and "reflexivity." In taking the account of another, actors interpret gestures (especially talk) in light of the context – both linguistic and situational. Stocks of knowledge are used to discover the contextual meaning or indexicality of words and other gestures, whereas stores of ethnomethods enable actors to determine what portions of such talk and non-verbal cues are critical to the reality being asserted by an account. However, actors also interpret accounts of others in terms of their own accounts or reality – what is referred to as reflexivity. Reflexivity leads individuals to interpret others in a somewhat self-serving manner – seeing what they want to see and disregarding any discordant information that would violate or modify personal accounts.

Thus, individuals approach an interaction episode with the presumption, unless or until proven otherwise, that they share a common and external world with others. This presumed commonality is often implicit and unacknowledged and is, itself, an "account" because it attempts to account for – make sense of and explain implicitly – what is real. Individual accounts are thus based on a presumed commonality with others and a reluctance to question potential discrepancies. Moreover, individuals

> ...share knowledge about classes of objects, types of utterances, varying interpersonal contexts, and procedures for connecting these in rendering or interpreting accounts. This knowledge is not fixed in the form of norms about how to behave; rather it is generative, offering individuals

> considerable flexibility in how to combine and recombine these elements of knowledge in constructing, or interpreting, an account (Turner, 1988: 97).

The use of stores of implicit ethnomethods (nonverbal cues – pauses, tone of voice, patterns of turn-taking, etc.) helps connect verbal communications (signed objects or words). Implicit ethnomethods relate the verbal and nonverbal in a way that informs others of how the account being offered should be interpreted. Thus, the use of ethnomethods help organize and attach objects, utterances, contexts, and other elements of actors' implicit stock of knowledge to the immediate interaction. They serve to order the elements of an account and sustain the sense that actors really understand each other and the interaction situation in which they are engaged. Should this mutual accounting processes fail, ethnomethods are brought to bear in an attempt to reconstruct, or remake, the account.

To Garfinkel, such accounts are all that is "real" – external reality is illusory and always constructed contextually through mutual account-making and account-taking of individuals in concrete settings. Though this may be overstating the case – this is not all that occurs in interpersonal processes – the concept of the "accounting" process is important. Much of interaction does appear to consist of subtle signaling and implicit interpretation of mutually intelligible accounts of "reality." The accounting process greatly facilitates other interpersonal processes (such as role-taking and role-making, framing, ritualizing and staging) and provides a deep background of suspended doubt and presumed trust that allows other interactional processes to proceed with greater ease.

Habermas and the Ideal Speech Act. One element of Habermas' critical theory is especially relevant to understanding interactional processes: the processes of communication, speech, and interaction that provide for the "ideal speech act." The ideal speech act refers to communication between individuals undistorted by forms of inequality and domination. Features of such undistorted communication are that (1) gestures are noncontradictory, (2) communication is public and conforms to cultural standards, (3) actors can distinguish between language *per se* and what language denotes and describes, and (4) such communication leads to intersubjectivity and the ability to create shared collective meanings. By focusing on intersubjectivity through undistorted communication, Habermas formulates the idea that communication involves more than words, grammar, and syntax; it also involves the making and taking of "validity claims." This conceptualization of interaction revolves around the process of asserting, and responding to, validity claims in the gestures and signals of others.

A validity claim is emitted and interpreted during communication and has three components. First, claims (both verbal and nonverbal) are made that assert that a particular course of action – as indicated through speech – is the most effective and efficient means of attaining an end. Second, claims are made that behavior is correct and proper in accordance with relevant norms and cultural standards. The third type of claims maintain that the subjective experiences as expressed in speech acts are sincere, authentic, and revealing of real subjective states. As actors talk, they make claims about the means-ends, correctness, and sincerity of their actions. Moreover, others involved in the communication accept or challenge such claims, leading to a process of "rational discourse" where actors negotiate over conflicting validity claims. To accomplish this negotiation, they must at least share certain common stocks of knowledge about what constitutes means-ends effectiveness, sincerity, and normative conformity in a wide variety of interaction contexts.

The elements involved in "claim-making" and "claim-taking" (accepting the claims of others) are illustrated in Figure A.8. This model suggests that, as individuals emit send and receive signals, they make and interpret claims about means-ends, sincerity, and appropriateness of the interaction. In the Habermas claiming—discourse—interaction process there are three basic interpretive patterns or stocks of knowledge. First are those stocks of knowledge relating to cultural traditions, values, and beliefs and to linguistic structures and their use in interaction. The second type of stocks of knowledge are those that indicate how to organize social relations and what patterns of interaction are proper and appropriate. The final stock of knowledge relates to patterns as to what "normal" people are like and how they should act.

Such stocks of knowledge, or interpretive patterns, represent criteria shared among individuals. These patterns are used in the human capacities for speech and discourse, deliberation, and indexicality to assert (make) validity claims for themselves and to interpret (take) claims of others. This process is sometimes conscious and made with deliberation; at others, it is unconscious and occurs without prior thought (the direct causal paths from stocks of knowledge to speech and discourse and to indexical interpretation). Others respond by accepting, revising or challenging the claims while making their own claims or counterclaims. If claims are challenged, "discourse" ensues and the interaction cycles around claims and counterclaims until understanding is attained and each other's speech is perceived to exhibit means-ends effectiveness, normative appropriateness, and sincerity as measured against the three types of "stocks of knowledge."

This process is extremely subtle, complex, and often implicit in several respects. First, the claims and counterclaims are typically unrecognized by the individuals involved. Second, interactions are difficult to sustain unless individuals implicitly adjudicate and reconcile their respective claims. Third, the application of interpretive patterns or stocks of knowledge is highly indexical and situational such that the context often determines what constitutes means-ends effectiveness, sincerity, and appropriateness. The stocks of knowledge can be used in highly flexible ways, assessing claims and contexts simultaneously. Finally, as individuals acquire experience in the process of making, taking, adjudicating, and reconciling claims, stocks of shared knowledge and capacities for interactive discourse are increased. These iterative processes (i.e., the process of learning through experience) maintain the stocks of shared interpretive patterns that produce and reproduce social macrostructure.

Turner's Synthesis

Turner's dynamic model of interactional processes, based on a synthesis of the ideas sketched above, is presented in Figure A.9. In essence, the model is an elaboration of the final outcome variable in the model of motivational processes (Figure A.4) – signaling and interpreting. As individuals mobilize energy (i.e., are motivated to engage in interaction), they signal and interpret in terms of the dynamics of the synthesized model of interaction.

Deliberative capacities are used to project self-references into an interaction situation. Self-references are grounded in an individual's conception of self and guide the process of role-making which, in turn, affects the individual's stage-making and ritual-making activities. Secondarily, these self-references affect frame-making through role-making, in turn affecting account-making and claim-making efforts. In using their deliberative capacities to project self-references, individuals draw on stocks of knowledge which also impose a frame on the situation. The stocks also help in the selection of relevant role conceptions and staging procedures, ethnomethods, and claims. Role-making and frame-making exert mutual effects on one another. As individuals seek to use stocks of behavioral sequences to make a role consistent with self-references, these stocks help them impose a frame on the situation. Conversely, as actors use stocks of knowledge about physical, demographic, sociocultural, and personal frames, these stocks impose limits on the kinds of roles that they can make for themselves.

In turn, individuals use staging and ritual as major, though not exclusive, vehicles for signaling their role, while employing ethnomethods (account-making) and validity claims (claim-making) a partial means for communicating how they have framed the situation. The end result is a collage of gestures, operating at many different verbal and nonverbal levels, that signals information to be interpreted by others. As the model suggests, such interpretation is reflexive in that individuals interpret their own gestures and, to varying degrees, filter and interpret the signals of others through the prism of their own framing, role-making, ritual, accounting, and claiming activities.

However, interpretation is not entirely reflexive. The signals and gestures of others are interpreted by using deliberative capacities and stocks of knowledge to role-take, frame-take, stage-take, ritual-take, account-take, and claim-take. The role-taking process is more conscious and deliberative than role-making. Individuals use stocks of knowledge to assess the roles that others are attempting to make for themselves, especially with respect to staging and ritual activities. Role-taking may not always be conscious and deliberative but it is rarely far from an individual's capacity to think about and articulate the "meaning" of others' gestures. In contrast, frame-taking is more implicit, especially when account-taking and claim-taking are the basis for interpreting the framework being imposed by others on a situation. However, if actors rely primarily on role-taking to understand another's gestures, then this process of frame-taking is more explicit and subject to conscious reflection and deliberation.

Just as role-making and frame-making circumscribe other signaling processes, role-taking and frame-taking initially guide the process of interpretation. Individuals will attempt, at least initially, to determine the role(s) and frame(s) of other(s). To do so, they rely heavily upon the staging, ritual performances, accounting, and claiming of others. However, unless these can suggest roles and frames as well, the process of interpretation will be disrupted and actors will become more conscious, deliberative and reflexive about "what is wrong." When role-taking proves ineffective, actors more consciously scrutinize the gestures of others for their role-making content; and in particular, they will be attuned to what the staging and ritual activities of others tell them about the underlying role(s) being asserted by others. Similarly, when frame-taking is ambiguous, individuals delve further into their stocks of knowledge to determine what the accounting and claiming activities of others tell them about the frame being imposed by others.

Whether interpreting is problematic or not, it influences the process of signaling. If framing is problematic, actors signal this through their own gestures, particularly with ethnomethods (account-making) and validity claims (claim-making). In addition, if role-taking is ambiguous, individuals signal this to others, especially through staging and ritual. Of course, when interpretations have created clear roles and frames as well as understandable accounts, claims, stages, and rituals, then signaling will reflect this fact and will, in al probability, proceed without great effort or conscious deliberation.

The result of these signaling and interpreting processes is mutual role-taking/making, framing, validating, accounting, staging, and ritualizing. Through such mutual agreement over roles, frames, accounts, stages, claims, and rituals that an interaction becomes structured. Such structuring, or ordering of interaction in time and space, can feed back and circumscribe interpreting and signaling processes.

Structuring Processes

As motivated individuals engage in mutual signaling and interpreting, social interaction is sustained across time. Such sustained interaction is accomplished through "chains of interaction" where past interactions and encounters are resumed at essentially the point where they were broken off or interrupted. These chains involve remobilization of past motives, remaking of roles, reframing, restaging, reaccounting, revalidating, and retaking of roles in a manner that repeats the basic form of the previous interaction.

Repetition of the basic form of interaction is facilitated and sustained by, and through, structuring dynamics. Structuring processes guide and circumscribe the resumption of interaction in its previous form by providing a template so that less energy is expended to restructure and reconstitute the interaction – individuals do not enter subsequent interaction with a "blank slate." If structuring processes are well established, the motivational energies and interactional activities of individuals can be channeled in relatively clear and unambiguous ways, requiring less negotiation over roles, frames, accounts and other motivational and interactional processes. Without some structuring mechanism, every reencounter of individuals would involve so much interpersonal effort that the participants would exhaust themselves. Social order depends to a large degree on the structuring of recurring interactional sequences.

Foundations

The conceptual foundation for the development of a dynamic model of structuring processes is provided through an analysis of Weber's action theory, Durkheim's views on interpersonal structuring, Simmel's transfer model of structuring processes, and Mead's model of interaction and social structure. Five important dynamics are identified in these early efforts: the creation and use of norms; the ordering of space; the emission of rules; the categorization of situations and others; and the stabilization of resource transfers. In addition, three conceptual elements of Parson's "implicit" model of interpersonal structuring are incorporated.

First, Parsonian theory stresses the normative element of structuring – exchange relations and transfers of resources are guided by norms. If these transactions prove sufficiently profitable over time and/or meet system needs, they reinforce norms and the more general value orientations that help structure interactions. Second, interactions that become structured involve the stabilization of resource transfers using generalized symbolic media – the exchange media that are appropriate for any particular exchange of resources. Interaction is more easily structured when individuals "know" the relevant media for an exchange of resources and when there is agreement about what media are to be used across exchange transactions. Such knowledgeability about media implies that individuals categorize situations in terms of the kind of media – power, influence, affect, approval, etc. – relevant to the specific situation. Finally, the third conceptual idea from Parsons suggests that interaction situations are categorized by individuals and that this categorization is used to select appropriate means and media for use in interaction sequence. Thus, the structuring of interaction depends on a mutual categorization that is then used to select the appropriate means and media for completing the transfer of resources and for giving predictability to subsequent transfers.

With these considerations as a foundation, Turner turns to an analysis of five contemporary approaches to the explanation of structuring processes: the exchange-theoretic model; Collins' exchange-ritual model; the interactionist model; Goffman's model; and Giddens' structuration model. These provide the foundation for the synthesized model of structuring processes.

The Exchange-Theoretic Model. Central to exchange theory is a concern with how interpersonal processes are "...implicated in the emergence, maintenance, and transformation of social structures" (Turner, 1988: 137). This essentially deals with the questions of (1) how exchanges of valued rescurces create patterns of differentiation (especially with respect to power and prestige) and (2) how such differentiation becomes integrated or "balanced" into a structural pattern. These are reflected in Figure A.10.

Existing macrostructural arrangements (i.e., the relatively stable networks and patterns of differentiation among actors in a population) determine the distribution of valued resources among individuals. Macrostructures are usually presumed to result from past micro exchanges (thus, the feedback back from exchange to macrostructure). Given that the existing macrostructure "determines" the current distribution of resources, individuals see some of the resources controlled by others as valuable and are willing to give up some of their resources to obtain those not currently controlled or owned. In order to "earn the most profit" (that is, maximize net return after incurred costs) from the exchange, individuals often engage in mutual impression-management to disguise their desire for the resources of another and to indicate the desirability and benefits of their own. These efforts at impression-management (e.g., "salesmanship") and negotiation result in the actual exchange of resources. However, these exchange interactions are guided by norms of "justice" and "fair exchange" as evolved from past exchanges and institutionalized in the value orientation and cultural aspects of macrostructures. Patterns of differentiation (differential distributions of resources and a degree of specialization) and relatively stable networks of exchange interactions emerge from these exchanges as they are repeated over time.

The degree of differentiation among individuals, in terms of power and prestige, is shaped by the respective values of resources under their control and by the number of other individuals from whom they can secure those resources. Power and prestige differences are most likely when the resources controlled by individuals are of significant differences in value (inequality) and when valued resources are monopolized – when those who find the resources of another particularly valuable and cannot obtain them elsewhere (scarcity of alternatives). Equitable (or "peer" relations) are most likely when there is little inequality in the distribution of resources and alternative sources of valued resources are not scarce. Under these "peer" conditions, actors exchange resources for approval and convenience. In the short term, these exchange relations tend to become integrated (in "balance" or equilibrium) since individuals come to accept their respective payoffs as judged by the "market value" of their resources and by norms of fairness and justice. Such integration and balancing stabilize the "rate of exchange," thus sustaining and reinforcing the macrostructure and the norms of fairness and justice.

Therefore, from an exchange perspective, what provides structure to social interaction is the stabilization of resource transfers through balancing and integration (i.e., the acceptance of payoffs/profits). This stabilization is facilitated by norms that specify what rates of exchange are fair and just. Thus, as long as interactions involve profitable (to all parties of the exchange interaction) exchanges of resources that are defined as fair, they will be repeated. As these exchange interactions are repeated over time, structuring occurs in two ways.

First, repetition of exchanges sustains the existing macrostructural conditions that (1) influence the distributions of resources and individuals and (2) at the same time reinforcing the norms that define what is fair in any exchange. Such feedback from repetitive exchanges to macrostructure serves to set conditions and limitations for future exchanges through maintaining/altering distributions of actors and resources and by reinforcing/challenging the norms of fairness and justice. Second, repetition of exchanges produces structure without reference to consequences for macrostructural processes. If actors receive rewards at any particular point in time, they will likely anticipate and accept their respective payoffs in the next exchange encounter – as long as established ratios of payoffs and norms of fairness are not violated.

Thus, the exchange-theoretic model extends the basic utilitarian premise (of the individually focused model of motivation) to structuring by way of a series of repeated and recurring dyadic exchange relationships. Three important propositions follow from this approach. (Note: All of the propositions listed in Appendix I can be found in Table A.1).

Proposition A.1: The structuring of interaction depends on the stabilization of resource transfers across time.

Proposition A.2: The structuring of interaction depends on the ability of each actor to realize some profit.

Proposition A.3: The structuring of interaction depends on the assessment of each individual actor that the exchange is fair and just with regard to relevant norms.

Collins' Exchange-Ritual Model. From the exchange-ritual perspective proposed by Randall Collins, social interaction is primarily motivated by a "need for group membership" and leads to interactions consisting primarily of conversational exchanges (Figure A.11). Most conversations are typically (though not always apparently) about group inclusion/exclusion issues with individuals "spending" their "emotional energy" and "cultural capital" in order to sustain and enhance their position in an ongoing group context. Within this framework, macrostructural conditions serve mainly to constrain what can occur in micro interactions. These macro level conditions serve to determine (1) the number of individuals involved in the interaction situation, (2) the spatial distribution of individuals, (3) the distribution of relevant resources among individuals, particularly with regard to levels of emotional energy and cultural capital, and (4) the temporal duration of the interaction – the length of time that individuals will interact. Macrostructures are, again, a result of past interaction. Repetitive "chains of interaction" recurring over time create the macrostructural arrangements that circumscribe and constrain subsequent interactions.

These recurring interactions are conceptualized (by Collins) as "interaction ritual chains" in which individuals mobilize appropriate emotional energy (e.g., sentiments, feelings, dispositions) and cultural capital (e.g., memories of past experiences, control of physical props, knowledge, authority). This energy and capital is expended in conversational exchanges with others. The kind and degree of resources necessary for the exchange depends on the particular situation which individuals classify as one of three types: work/practical, social, or ceremonial. The result of these exchanges is that individuals realize some level of profit (i.e., positive emotions and/or increased capital) with respect to their place or position in an ongoing group context.

Conversational exchanges become a "ritual performance" because they revolve around and address a common focus (group membership) that arouses people's emotions with respect to their sense of group involvement. In other words, the basic motivational force in human interaction (the need for a sense of membership in the group) is linked to how people interact (ritualized conversational exchanges using emotional energy and cultural capital to sustain/enhance a sense of group membership). These interactions become linked together over time as an individual's "profit" from one conversational encounter becomes stored as memory and subsequently used to classify situations and mobilize a given level of energy/capital in the next encounter. This exchange of (conversational) resources becomes stabilized as actors accept their place in the ongoing interactional context.

If there is inequity in the organization of this interactional context (i.e., some individuals control more cultural capital than others or can mobilize more emotional energy) the exchange becomes ritualized in a second sense. Stereotyped sequences of behaviors allow subordinates to invest as little capital and energy into the situation as possible, while freeing superordinates from the responsibilities of constantly monitoring the actions of subordinates. Such stabilization of resource transfers and ritualization of exchange interactions help sustain the distribution of energy and capital among individuals and, in turn, determines the larger macrostructural arrangements. Four propositions derive from Collins' exchange-ritual model:

Proposition A.4: The structuring of social interactions revolves around resource transfers, especially with respect to issues of group membership.

Proposition A.5: As resource transfers are stabilized through established ratios of payoffs and rituals, they become more structured, making it easier to link encounters together in chains of interaction.

Proposition A.6: The categorization or classification of situations (work/practical, social, ceremonial) facilitates structuring by indicating what emotional and cultural resources are relevant to a conversational exchange and what rituals are most appropriate for such exchanges.

Proposition A.7: The particular categories and resources to be employed in an encounter is circumscribed by demographic/ecological conditions, especially the number and distribution of actors in time and space.

The Interactionist Model. Though interactionist theory stresses the primacy of interpersonal processes as a general explanatory principle it does not, in general, actually explain how structure is created and sustained through those interpersonal interactions. However, elements of interactionism involve the structuring process. In the interactionist model, social structures are sustained through a series of reinforcement/challenge processes arising out of individuals' efforts to construct patterns of "joint action" (Figure A.12). These reinforcement processes highlight the implicit behaviorism in the interactionist approach, especially as articulated by Mead and the Chicago School of symbolic interactionism. Individuals find rewarding those behaviors that (1) increase the accuracy of role-taking and role-making, (2) confirm self as an object, (3) sustain definitions of situations, (4) affirm the salience of norms and generalized perspectives guiding conduct, and (5) place actors in positions and roles. Conversely, if efforts at joint action do not provide this reinforcement, pressures for change in the social structure increase.

Thus, social structure is a process revolving around reinforcement patterns. Once created, however, social structure dictates the relative location (positions) of actors in situations as well as the relevant norms and perspectives. In turn, the position of actors determines which aspects of self will be seen as relevant in an interaction, whereas the increased salience of norms and generalized perspectives (meanings, attitudes, orientations, feelings, and dispositions) influences the "definition" of the situation that individuals develop. Such definitions are reciprocally related to self in that one's self-conception circumscribes what one sees as important in a situation, while being influenced by these very perceptions. Role-making is primarily influenced by self, as qualified by norms, generalized perspectives, common definitions, and role-taking, whereas role-taking is principally influenced by common definitions of situations, as circumscribed by actors' relative positions and by their efforts to make a role for themselves.

Social structure, then, is a process of active construction of joint acts across time – past joint actions determine relative positioning of individuals in status-roles and make certain norms and perspectives more salient than others. Thus, there is a heavy normative element in interactionism. Moreover, there is a pronounced emphasis on position in a larger network of positions. Social structures are also created and held together by people's ability to construct common definitions about the elements of a situation. Through mutual role-taking, they can agree upon the categories of others and objects that exist in a context and that, as a consequence, dictate the range of appropriate responses, norms, and perspectives to be invoked in a particular situation.

Though the interactionist approach is limited in explaining the emergence and maintenance of social structure (because of its implicit behaviorism), two propositions deriving from interactionism relate to the structuring process.

Proposition 6.8: Social structure will be sustained to the extent that it enables individuals to maintain positive self evaluations about those dimensions of their self that they see as important.

Proposition 6.9: Individuals orient themselves to situations in terms of common cognitions. That is, in defining social interactions, individuals tend to look for commonalities with others in defining a particular situation.

Goffman's Dramaturgical Model. Dramaturgical analysis provides elements of Turner's (1988) synthesized model of interactional processes, especially with regard to signaling and interpreting. Goffman's perspective also provides insights into the processes that structure interactions across space and time. Interaction occurs within a macrostructural context that determines not only the distribution of actors across space and time, but also the salience of shared cultural orientations (though the properties of these orientations are vague in Goffman's analysis).

Within the spatial, temporal and cultural contexts and constraints determined by macrostructure, individuals seek to frame situations and present themselves in a favorable light (Figure A.13). Frames further circumscribe the range of potential responses in a situation and self-presentations provide the motivational energy for the interaction to proceed. All of these factors allow the individual to ritualize and regionalize their interaction. Ritualization involves the emission of stereotyped sequences of gestures. Regionalization (manipulating the geographic, ecological and demographic context of an interaction), through the use of space and physical props, circumscribes the emission of these rituals providing the physical cues for different types of gesturing sequences.

Subsequent interactions can proceed smoothly if agreement can be reached over these issues because individuals "understand" what the physical and temporal parameters of their interaction "mean." The processes of ritualizing and regionalizing, in turn, feed back and sustain the macrostructure by ordering people in space and time, while reaffirming cultural orientations. Thus, ritualized and regionalized interactions reinforce the very macrostructure that initially encouraged the use of certain rituals as well as the ordering of space and time. As interaction in more and more contexts are regionalized and ritualized, structure is built from recurring interactions. Thus, a complex society that requires considerable movement of individuals into and out of many different kinds of situations depends upon a high level of knowledge about the meaning of diverse rituals and regions.

Dramaturgical analysis provides two propositions concerning the structuring process.

Proposition A.10: Those interactions that can be ordered in space/time and that can be sequenced in a predictable (ritual) form will be more readily repeated and linked together in chains of interaction.

Proposition A.11: As individuals in a society acquire knowledge about what physical props, spacing, staging, and behavioral sequences "mean" in varying contexts (the interaction is regionalized), they can organize their responses without great interpersonal effort.

Giddens' Structuration Model. Giddens conceptually integrates forces that mobilize agents (by blending concepts from psychoanalytic theory, interactionism, and phenomenology/ethnomethodology into a theory of motivation) with those forces that structure interaction in time and space (Turner, 1988).[8] For Giddens, "structure" denotes the "rules" and "resources" that individuals use to extend their interactions across space and time. Rules are "generalized procedures" that people employ as a methodology or formula for organizing their responses, whereas resources are "facilities" that actors can draw upon to get things done during an interaction.

The two basic kinds of rules are (1) normative rules that are used to create rights and obligations in an interaction and (2) interpretative rules that are employed to generate "stocks of taken-for-granted knowledge" in a context. Likewise there are two types of resources: (1) authoritative resources are those organizational capacities that actors possess and draw upon in a situation to control and direct the pattern of interaction; and (2) allocative resources are those material features of the situation – props, artifacts, goods, etc. – that actors use to coordinate their responses and accomplish tasks.

The "structure" of a situation consists of various rules and resources that individuals can employ to organize their interactions (Figure A.14). In the structuring process, actors create norms, facilities, and interpretative schemes. Rules and resources are capable of being combined and recombined to create varying norms, facilities, and interpretative schemes but there is often an institutional constraint on what rules and resources are available to actors and

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[8]However, as Turner (1988: 145) notes, Giddens has little to offer on the actual processes of interaction (i.e., gesturing, signaling and interpreting processes).

on how they can be transformed. Thus, many interaction contexts are lodged in institutionalized patterns that have been built up from past interactions and that circumscribe the rules and resources currently available to individuals.

As norms, facilities, and interpretative schemes are created, they are used for mutual sanctioning, communication, and use of power. Emerging from these interpersonal activities is an ordering of interaction in terms of routines and regions. Routinization organizes an interaction across time; regionalization orders an interaction in space. As situations become routinized and regionalized, actors reproduce the very structures and institutions that determine the resources and rules available to them. Routines stretch interaction across time by enabling actors to interact in predictable ways during a single encounter or in successive ones. Five interpersonal mechanisms are used to sustain routines: (1) the use of rituals that mark the opening, sequencing, and closing of a particular pattern of interaction; (2) the use of "turn-taking" methods to assure that conversations proceed in a predictable form that maintains the routine; (3) the use of "tact" to create the sense of decorum necessary for sustaining routines; (4) the use of signals to mark individuals' respective (status) positions in a situation; and (5) the use of frames as markers for indicating what range of behaviors and demeanors is appropriate for maintaining a routine.

Regionalization, in Giddens' usage, refers to the notion that interaction has a geographical element as well as a serial ordering of responses across time. Regions (referred to as "locales") vary in terms of their physical and symbolic boundaries, their degree of connectedness to broader institutional patterns, their span and extension of physical space, and their duration in time. As individuals interact, they use rules and resources to mark the geographical boundaries of the interaction, to connect their use of space to broader institutional patterns, to partition space in which the interaction occurs, and to decide upon the time period during which the space will be used. Such "staging" practices enable individuals to increase the predictability of their responses, whereby meeting basic motivational needs for security and trust, while reproducing structure and institution.

These lead to three propositions relating to structuring processes.

Proposition A.12: There is a normative element to social interaction and those norms are malleable tools for ordering interaction.

Proposition A.13: Routines and routinization, which increase predictability and the habitual nature of individual responses, promotes the structuring of interaction across time.

Proposition A.14: Regionalization, which orders actors in space, increases the ability to maintain the interaction across time.

Turner's Synthesis

Individuals are motivated to engage in interactions with other individuals (through mutual role-taking and making, staging, validating, ritualizing, and framing) in order to obtain (through exchanges with others) valued resources. In order to "gain" those required resources, energy must be expended in seeking out and signaling that an exchange relationship is desired and resources must be "given up" in order to facilitate the exchange. In this exchange relationship, both parties hope to make a "profit" (the exchange is mutually beneficial), thereby encouraging further exchanges. These exchange relationships (interactions) recur over time in "chains of interaction" that become patterns that create the emergent property known as "social structure." From this perspective, social structure is not a "thing" (a "social fact" in the Durkheimian sense) but, rather, a "...process in which individuals produce and reproduce patterned sequences of interative responses" (Turner, 1988: 149).

This established pattern of sequences becomes a "mental template," "schema," or "cognitive map" for future interaction episodes. These cognitive schemes can be learned by others so that successive sets of actors can enter situations and repeat lines of behavior created by others. This implies two aspects to the process of structuring.[9] First is the notion that structuring implies an overt (and external to any one individual) patterning of behavior in time and space. Second is the implication that structuring also has an (internal) cognitive component involving a mental model of information about what interactive sequence apply to varying types of situations.[10]

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[9]Turner (1988: 149-159) notes that this duality presented Durkheim with a "conceptual dilemma." Durkheim's well known and oft quoted notion of social structure as a "social fact" that is external to, and constraining of, individuals was later modified to include the idea that there is also an internal component to social structure; that in some sense social structure is a mental construction that penetrates individuals and is organized in individual consciousness.

[10]The arguments developed in this section provide the basis for the discussion of the informal interaction order in Chapter 7. The interaction order is characterized by a dominant mode of exchange (either GES or RES) that is ingrained in the cognitive schema of organizational members and that provides the informal control mechanisms in the connectionist model.

In his synthesis of structuring processes, Turner stops short of a consideration of how these patterned sequences of interactions translate into macrostructural phenomena.[11] The much more limited issue addressed by the synthesized model of structuring processes is to consider "...how it is that individuals are able to pattern and sequence their interactions across time and space" (Turner, 1988: 150). Drawing on his analysis of early conceptualizations of interpersonal structuring processes (Weber, Spenser, Durkheim, Simmel, Mead, and Schutz) and a series of propositions developed from the contemporary theories discussed in the preceding section, Turner derives six dynamic properties of structuring: categorization, regionalization, normatization, ritualization, routinization, and stabilization of resource transfers. The relationships between these are discussed below and displayed in Figure A.15.

Categorization. *Categorization* refers to process by which individuals view situations (and each other) in terms of consensually agreed upon categories. This process greatly reduces the amount of time and energy necessary for signaling and interpreting and, thus, facilitates exchange interactions. Once persons and contextual elements are categorized, appropriate responses are "preprogrammed" and interactional episodes can be

[11]It should be kept in mind that Turner's intent is not to create a model of macro-micro linkages. Indeed, contrary to the model presented in Chapter 7, he contends that such efforts are premature.

entered into with a minimum of deliberation. These categories, either learned through experience or from others, are carried in an individual's stock of knowledge and contain information about how to orient one's self and behave (in general terms) in a given type of situation. Without such categorization of persons and situations, the structuring of interactions would be difficult, at best. Each interaction would constitute a unique situation requiring new (and unknown) responses at various points in any particular interaction episode, and in all subsequent interactions.

A provisional typology of nine categories suggests that individuals categorize interaction episodes differently according to (1) varying situations and (2) level of intimacy with the other. In the first case, individuals initially assess a situation as being one of three types. These types order an individual's response according to a classification of the situation as either work/practical, ceremonial, or social. This categorization gives at least an initial indication of the types of activities, responses, and behaviors that are appropriate to the situation and facilitate sustained interaction. Further, if actors are to enter new situations, there must be markers (words, nonverbal gestures, physical props, etc.) that give information as to the relative category.

In addition to classifying situations as to types, individuals classify or type each other as representative of categories. Such classification varies with the degree of intimacy with which people view each other. At one extreme, they see each other as intimates with whom they feel in true intersubjective contact (i.e., a "strong" tie). At the other extreme, they view the "other" as categories whose subjective states they presume by virtue of their assumed representation of particular "types" of individuals (i.e., "weak" ties). These are not to be viewed as strictly delineated categories (an either/or process) but rather as a continuum of categories. Thus, there is a middle category where others are seen as more than "types" but less than intimates or vice versa; where others are seen as typifying certain classes of individuals, but having some personal specifics.

Based on joint consideration of these two dimensions (the context as work/practical, ceremonial, or social; the other as intimate, person, or category), individuals organize their responses to, and behavior in, interaction situations based on one of nine possible categories. The critical point is that the structuring of interactions is greatly facilitated when individuals can organize their responses based on one of these nine categories.[12] The categories are provisional in that they can be moderated, modified, elaborated or changed depending on the progress of the interaction. However, such categorization makes responses predictable, enables people to enter new situations and understand what is expected, and allows a resumption of interactions where they were left off.

[12]This explains why many organizations have "rules" or norms prohibiting fraternization between superiors and subordinates. Such fraternization results in confusion as to the appropriate categorization of the interaction.

Regionalization. *Regionalization* stresses the importance of geographic, demographic, and ecological factors in the structuring process. Structuring of interactional processes is

> ...likely to be influenced by such considerations as the span of space in which the interaction occurs, the physical props that exist, the objects dividing space into "regions," the number and distribution of individuals in regions, and the movement of people into and out of the overall space and its various subregions (Turner, 1988: 153).

These (demographic, geographic, and ecological) variables, to some extent, determine the flow of the interaction. A large physical space will have different interaction patterns that a small space; a space divided into subregions (by furniture, partitions, walls, etc.) will have different interactional dynamics than an open space; a crowded space will affect interaction patterns differently that a sparsely populated one; and so forth.

Although regionalization circumscribes the range of what is possible in an interaction situation, the actual structuring of the interaction sequence across time is the result of shared conceptions of what those demographic, geographic and ecological variables (space, regions, numbers, movements, and objects) actually "mean." The structuring of an interaction thus requires relatively stable ecological and demographic conditions *and* a general consensus over what these conditions indicate as the appropriate lines of conduct. Through socialization and interactive experience, individuals develop stocks of knowledge about interactive ecology. This knowledge is used to regionalize interaction in time, thus contributing to the structuring process. This knowledge is a subset of an individual's more general stock of knowledge and is cognitively organized around four dimensions: the meaning of space in varying contexts; the meaning of objects in different spatial settings; the meaning of the division or organization of space in different contexts; and the meaning of interpersonal demography – varying numbers, distributions, and movements of people in different settings. As Turner (1988) notes

> ...for an interaction to become structured, actors must agree what the space in which they are located signifies (a floor of offices, classroom, football stadium, etc.); they must accept the significations of objects in this space (desks, doors, carpets, chairs, nameplates, turnstiles, etc.); they must understand what the division of space into regions means (offices, corridors, conference rooms, sections, rows of chairs, etc.); and they must know what the number, distribution, and movement of people in the situation indicates (e.g., crowds at a stadium, receptionist in an office, students in a classroom, etc.) (Turner, 1988: 155).

Though this may seem obvious, regionalization is a complex and subtle process. It is also crucial. Without regionalization, actors would need to expend much time, effort, and energy to understand and determine the appropriate behavior in any particular physical context. Regionalization offers a host of cues to guide behaviors, provide an orienting framework, and indicate which range of norms, rituals, categories, and resources are most relevant.[13] Without such regionalization, a greater burden falls upon interpersonal signaling and interpreting. When ecological, geographic, and demographic cues can be

[13]The implication is that a given set of behaviors may be appropriate in a particular context (or region) while those same behaviors are seen an inappropriate in other situations. "Violations" of this consensus results in comments such as "This is neither the time nor place" for a certain act.

relied on, the interaction can flow more readily and can be more easily resumed at some point in the future.

Normatization. *Normatization* refers to the dynamics involved in providing not only information about the rights and obligations relevant to the interaction, but also to the generation of more generalized "interpretative schemes" that allow specific normative criteria to be modified, altered, and adjusted in varying situations. This dynamic view of normatization relies on three elements. First, norms are not so much prepackaged sets of expectations tied to specific positions and categories, as they are cataloged general stores of information about obligations, rights, duties, and interpretative perspectives. Second, norms are "generative" in the sense that individuals carry in their general stocks of knowledge understanding about the procedures by which normative information is categorized, stored, retrieved, assembled, and reassembled for use in situations. Third, norms are "facilitative" in that actors construct normative agreements by drawing upon their stores of information about rights, duties, obligations, and interpretations and by using these agreements to order their current and subsequent responses in situations. This shift in emphasis from a static and functionalist conceptualization of norms[14] to stress the more generative and transformable nature of normative behavior as

[14]Turner (1988) critiques this "traditional" view of norms on pages 156-157.

individuals negotiate and renegotiate their general interpretations of, and respective obligations in, specific contexts.

Normatization is closely relate to categorization, which implies that certain kinds of responses are "owed" to others. Categorization helps specify what obligations are relevant and salient in an interaction, while the invocation of normative obligations facilitates the organization of responses in terms of categories. Sometimes, of course, individuals confront situations where generative and transformative options are very limited, since past interactions have created relatively clear and consensual "rules" and "expectations" about what should occur. Even in this case, however, these established normative expectations constitute only a general framework within which actors can create more specific agreements about how they should interpret and behave in a situation. The point is that, though norms may serve to limit and circumscribe behavior in interpersonal interactions, the active and dynamic process of normatization suggests that some leeway exists and allows for the negotiation of, and transformation of, normative values in interaction. However, though norms are transformable, this transformation often can occur only at a high cost – most often exceeding what individuals are prepared to "pay" in terms of the motivational energy and increased demands on signaling and interpreting. Thus, as part of their stocks of knowledge, people carry around in the heads prepackaged normative orientations that they draw upon in predictable ways and use to guide their conduct.

Thus, as is the case of regionalizing dynamics, normative information is a cognitive subset of more general stocks of knowledge which, like all stocks, are acquired through past interactions and experiences. This (normative) subset consists of three interrelated stores of information: (1) knowledge about rights and duties, (2) knowledge about how to interpret, and (3) knowledge of the procedures for using (1) and (2).

Stores of information about rights and duties comprise individuals' cataloged information about what to expect in situations. This suggests that the information is stored and organized in systematic manner that can be retrieved and made available for use in a situation. This "catalog" can be conceptualized of as having three distinct areas of content: stores of rights and duties that apply to general types of situations and to all individuals within a given culture and society (e.g., norms of politeness, demeanor, decorum conversational turn-taking, spacing, etc.); norms of rights and duties in those highly institutional contexts evident in all societies (e.g., work, kinship, religion, politics); and norms of the rights and duties negotiated and selectively remembered in specific situations over the course of a lifetime. As individuals interact, they invoke normative information about expectations of people in general, modify this information in terms of any institutional context that may (or may not) be relevant, and then qualify this information even further in terms of actual experiences in the same or similar situations.

The process of filtering and focusing this information about rights and duties is facilitated and circumscribed by the two other subsets of normative information. First, individuals order their knowledge about how to interpret situations and others into schemata, or some loosely organized system of interpretative elements, revolving around the relevant attitudes, meanings, feelings, dispositions, and other orienting cognitions in a situation. This "cognitive map" both (1) filters perceptions of a situation and (2) orders the retrieval of information about rights and duties. Various interpretative schemata are organized around the categories of information about rights and duties: situation and people in general, institutional contexts, and those ordering specific past experiences. These three kinds of schemata are used simultaneously to denote a situation as an instance of specific past experience, as an element of an institutional order, and as a general type or category of interaction (e.g., work/practical, ceremonial, social). On the basis of this denotation, the individual selects information about the rights and duties that are relevant and that are to be used in interactions with others.

These elements concern the cognitive structuring of (1) norms that are relevant in various situations and (2) schemata that allow differentiation and denotation of a particular interaction situation. An additional element provides the rules and procedures for cataloging, ordering, combining and recombining, retrieving, and using information. These consist of (1) grammatical rules specifying how interpretative schemata and pieces of information are to be "strung together" to create a set of expectation, (2) rules of indexicality or context indicating the kinds of rights, duties, and schemata appropriate to varying types of situations, and (3) rules concerning adjudication of potentially discordant information about rights and duties, interpretative schemata, normative grammar, and contextual inferences.

Thus, a complex set of cognitive dynamics revolves around the process of normatizing situations. This normatization of a situation involves the capacity of individuals to invoke a similar interpretative schema for organizing their perceptions, to agree upon their respective selection of rights and duties, and to employ similar procedures for creating, contextualizing, and adjudicating normative elements. When actors cannot agree on rights and duties, schemata, and organizing procedures the interaction becomes stressful and difficult to structure. In general, actors are highly motivated to normatize situations because it enables them to structure their interactions in ways that meet the basic motivating needs (such as ontological security and trust) and avoids the expenditure of more energy than necessary to signal and interpret. The process of normatization thus facilitates the interaction process and the structuring thereof.

Ritualization. *Rituals* are stereotyped sequences of behavior that symbolically denote and emotionally infuse the ongoing flow of interaction. "Stereotyping" implies that the meaning of the behavioral sequence is "understood" (often only implicitly) by others and that the general direction of the behavior is thereby highly predictable. "Symbolically denote" implies that these stereotyped sequences of behavior mark some aspect of group involvement; that is, the rituals concern matters of group inclusion and they operate as a mechanism for denoting some dimension of a collective context. "Emotionally infuse" stresses that rituals mobilize feelings and motivational energy – feelings of diffuse anxiety are reduced to the extent that social interaction is successful in producing a sense of inclusion, trust, and security. These deep-seated needs are met by ritual activity. Thus, the ritualization of interactions create stereotyped sequences of gestures among individuals that mark the implicit solidarity of ongoing interaction and meet individual needs for group inclusion. In addition, stereotyped sequences increase the degree of predictability of individual behavior, thus reducing the energy needed for signaling and interpreting while at the same time reducing the (emotional) energy necessary to deal with anxiety and failure to meet basic needs.

Ritualization structures the interaction process through four primary mechanisms: opening and closing rituals, forming rituals, totemizing rituals, and repair rituals. Opening and closing rituals are sequences of behavioral gestures that signify the initiation and termination of an interaction sequence. These mechanisms serve to facilitate agreement as to when an interactional sequence has begun or ended and to ease a resumption of the sequence at a later time. Forming rituals involve the use of stereotyped behavioral sequences to order the interaction between opening and closing – they serve to indicate to the actors a direction and to increase the degree of predictability of the interaction. Thus, certain ritualized modes of behaviors and responses are appropriate depending on the type of interaction (i.e., work/practical, ceremonial or social).

Totemizing rituals involve the use of objects, words, or nonverbal gestures as symbolic means of reaffirming a sense of group involvement. These types of rituals place emphasis on the interaction itself and serve to reinforce the feeling that the interaction has importance to all participants. In general, these symbols must be performed and reciprocated for the interaction if a sense of commitment to the interaction is to be sustained by both parties.

Failure to use opening/closing, forming, or totemizing rituals result in disruptions of normal interactions. For example, if one actor should ignore a customary closing ritual, the next encounter will not proceed without a sense that the relationship has been disrupted and must be reconstituted before a resumption or opening of a new interactional sequence. Likewise, a violation of a forming ritual disrupts the structure and flow of the relationship and this "damage" must be repaired before interaction can proceed. Since disruptions are inevitable, repair rituals are a necessary and essential element of the structuring process. The structuring process could not occur without a set of behavioral sequences to signal efforts at restoring a breached, disrupted, or interrupted interaction. In each actor's stocks of knowledge are inventories of repair rituals that they can use to "smooth over" a disrupted interaction. Some of these repair rituals are generic and can be applied in most contexts ("Excuse me," "I'm sorry," "Sorry, I didn't know," etc.); others may be specific to a particular type of situation (work/practical, ceremonial, or social).

Thus, the structuring of interaction depends on agreement and understanding among actors as to appropriate opening and closing rituals, what forms of interactive dialogue are appropriate, what gestures will affirm the relationship, and what kinds of gestural sequences will repair a disrupted sequence. The more actors share knowledge of rituals and the more readily they are adhered to, the more likely an interaction is to exhibit continuity and to be resumed at subsequent times with minimum efforts. As knowledge is gained about classes of situations and the rituals appropriate to them, actors can move from one interaction to another more easily – even if the other party to the interaction has not been met before. Generalized and appropriate rituals are necessary for structuring to be elaborated beyond chains of repeated interactions among the same people.

Routinization. *Routinization* involves repetitive sequences of mutual signaling and interpreting ("habits") that are customary and habitual for the parties involved. Such routine and repetitive behavioral sequences serve to enhance the predictability of the interaction, without requiring great mental and interpersonal effort. Beyond rituals, which reinforce and signify the importance of the interaction, routines typically emerge out of interaction that must be sustained over time. Routines serve to structure ongoing interactions by providing an "ontological security blanket" and reduce the potential anxiety associated with situations where one must be alert to the gestures of others. Without routines, interaction would be exhausting; interactive structures, especially longer term ones, depend on each party routinizing their responses in order to conserve energy. Thus, routines make responses predictable and in doing so meet fundamental needs for trust and security.

Stabilization. *Stabilization of resource transfers* serve to structure and maintain interaction sequences in that, over time, actors come to accept a given type and ratio of exchanged material and symbolic resources in the interaction. Actors are motivated to realize a "profit" in such exchanges and, if an interaction yields an acceptable profit for each of the actors involved in the interaction, they are motivated to maintain the interaction and engage in interactive sequences that have been profitable in the past. Moreover, if the types and ratios of resources transferred are acceptable to individuals, these become normative expectations that are used to order and structure subsequent interactions. Knowing what types of resources are to be exchanged and what the rate of exchange will be reduces the uncertainty of a situation and the amount of interpersonal negotiation required for actors to sustain the interaction. Alternatively, when exchange ratios are in doubt, considered unfair, damaging to one party or the other, or subject to constant negotiation, it is difficult to sustain the interaction over time. Under these conditions actors are motivated to change the situation and unwilling to accept the existing interactive sequence as appropriate.

As discussed with respect to motivational dynamics, exchanges revolve around securing those material and symbolic resources that maintain a sense of group inclusion, confirm and affirm self-conceptions, promote a sense of facticity, provide for a sense of ontological security, and create a sense of trust. Thus, to the degree that resource transfers can stabilize around acceptable ratios of those valuable resources, an interaction will be more readily structured. The specific resources which are relevant and salient for meeting these needs is contingent on the personal experiences of the individuals and the context of a particular interaction.

Thus, the temporal and spatial structuring of dyadic interaction sequences and episodes depends on actors' mutual capacity to categorize, regionalize, normatize, ritualize, routinize, and stabilize their responses toward each other. This presupposes that individuals have stores of information about these dynamics and that they can use them appropriately in signaling and interpreting activities. If this is the case, basic motivational needs can be met, and the processes of signaling and interpreting are simplified.

Micro Dynamics

Out of such recurring interactions and structuring processes, over time, a characteristic interaction order develops. This is particularly true in an organizational setting where formal control mechanisms serve to alter, modify, constrain, canalyze and defines the pattern and configurations of connections in the organizational deep structure. This interaction order – characterized as either a GES or RES mode of exchange in Chapter 7 – serves as the informal control mechanism that drive complex organizational systems. This dominant mode of exchange is reflected in the cognitive schema of organizational members and this cognitive map guides the informal day-to-day interactions with others in the organization. Thus – not only do organizational formal control mechanisms drive the system of connections – informal mechanisms structured from the day-to-day micro-level dyadic interaction sequences among organizational members also serve to alter, modify, constrain, canalyze and define the deep structure of connections.

The problem of how these micro-level phenomena affect, and are affected by, macro-level phenomena central to the complexity science and the study of complex adaptive systems. Certainly, reductionist strategies of decomposing macro-level factors and viewing them as nothing more than aggregated micro-events have not been fruitful. However, the problems with linking macro and micro phenomena are great because

> ...vague references to "system reproduction" aside, how does one conceptualize the enormous number of micro events that are involved in macrostructures? What rules of aggregation of these events does one use to explain variable states of social differentiation, inequality, resource distributions, ecological distributions, and other macro-level processes? It is a lot easier, I think, to see how one of the macro-level processes constrains...than...to see how motivational, interactional, and structuring processes produce and reproduce macrostructures (Turner, 1988: 212).

The connectionist model presented in this analysis provides a beginning to the understanding of how such micro- and macro-level processes interact and how the structuring of micro-level dyadic interaction contributes – and inhibits –

macro-level organizational dynamics. Such an understanding results from efforts to integrate and incorporate complexity insights and a connectionist CAS perspective into contemporary theoretical approaches to explaining social structure and how it changes, develops and transforms.

APPENDIX B

GLOSSARY

GLOSSARY

One cannot understand the new with the vocabulary of the old.

Adaptation: Any change in the structure or function of a system that allows it to survive and reproduce more effectively in its environment.

Algorithmic complexity theory: Mathematical theory holding that the complexity of any object is directly proportional to the length of the shortest possible description of that object. This suggests that the object is maximally complex and random if the shortest description (algorithm) of the object is the object itself. In other words, the object is random if it is incompressible. For example, any *n*-digit sequence exhibits maximum complexity if the sequence cannot be reproduced by any algorithm that is appreciably shorter that the sequence itself. Ford (1983) presents arguments that suggest that maximum complexity implies randomness. See Casti (1994), Ford (1983) and Hofstader (1980).

Allogenic theory: A theory of systemic change that positions the driver and director of change phenomena external to the system or phenomena of interest.

Analytic theory: Pepper's (1942) categorization of theoretical structures where "complexes or contexts are derivative, not an essential part of the categorization" (Tsoukas, 1994). This suggests that the fundamental units of the system of interest are discrete, separable elements or factors. This type of theory is inherently reductionist in that it is assumed that the system can be decomposed into these discrete elements, allowing analysis of these elements in isolation from other components. Compare to synthetic theory. See Tsoukas (1994).

Antichaos: A term used interchangeably with *self-organization*.

Assumption of isomorphism: The assumption that levels of phenomena are totally separate and distinct but that elements and processes at various levels are isomorphic (i.e., they have the same structure). When a correlation between processes at separate levels is observed, this is presumed to suggest that similar processes and mechanisms are in operation at each level of phenomena.

Attractor: A method of describing the long-term behavior of a system. Equilibrium and steady states correspond to *fixed-point* attractors, periodic states to *limit-cycle* attractors and chaotic states to *strange attractors*. Strange attractor is often used synonymously with low-dimensional chaos or fractal behavior.

Autocatalysis: Catalysis (acceleration) of a reaction by one of its own products.

Autogenesis: Theory of system evolution introduced by Csányi and Kampis. "In the autogenetic process, the organization of the system (and of its parts) changes due to the functions of existing components. Thus autogenesis is possible *only if the stage of identical replication <autopoiesis> has not been achieved*. In that stage, the system is functionally closed and its replication continues as long as the environment does not change. There are no further organizational changes initiated by organizational causes, because new functions cannot originate. The system becomes an autonomous self-maintaining unity, a network of component producing processes which, through the functional interaction of components, produces exactly the same network which produced them" (Csànyi and Kampis, 1987: 237-238; emphasis added).

Autogenic theory: A theory of system change that positions the driver and director of change internal to the system or phenomena of interest.

Autopoiesis: Self-maintaining (Baker, 1993: 128). "A system is regarded as an autopoietic organization if it is an autonomous, self-maintaining unity; a network of component-producing processes that, through the interaction of the components, recursively regenerates exactly the same network that produced the components...From the organizational point of view, an autopoietic system is closed as it has no input or output" (Csányi and Kampis, 1985: 304; this definition is based on work by Varela and Maturana).

Bifurcation: A branch, when there are two distinct choices (or alternative trajectories) available to a system.

Change: An empirical observation of some difference in form, quality or state (i.e., spatial characteristics) in the system or entity over time (i.e., temporal characteristics).

Change process: The progression of change events that unfold during the system's or entity's existence. This process and progression of change events may be either *developmental* or *transformational*.

Complex Adaptive Systems: Macroscopic collections of many basic interacting elements that have the potential to evolve over time.

Complexity Sciences: The science of complexity refers to the study of the collective (micro) behavior of many basic but interacting units and how such (macro) collectivities evolve, change, develop and transform over time. The "complexity sciences" is a term used to denote a variety of approaches to the study of such systems. See Figure 3.1.

Contextualism: Approach to formal knowledge based on *synthetic* and *dispersive* theories (Pepper, 1942). Contextualism considers the appropriate object of study the *whole*, rather than discrete components, as the object of study. Unlike the claims of analytic (and formism) theories, reality is not algorithmically compressible. Like formism, however, contextualism is based on the dispersive claim that there is no underlying nomothetic structure to this *gestalt*. Thus, the phenomena of interest resists attempts at reduction and must be taken as a whole; further, there is no search for underlying structures that would explain the behavior of the whole. Ideographic and historical approaches are examples of research methods based on a contextual approach. See Tsoukas (1994).

Control Mechanism: In general, control mechanisms refer to the rules, laws or logic that determine the nature of the linkages between elements in a complex adaptive system (CAS). In the connectionist model of social system dynamics developed in Chapter 7, organizational control mechanisms are posited to reside in the cognitive schema of organizational members. Social system control mechanisms are both formal (1^{st}, 2^{nd} and 3^{rd} order formal control mechanisms) or informal (RES or GES mode of exchange) as reflected in the dominant interaction order. Such control mechanisms direct social system dynamics by altering the configuration of the deep structure of connections that define the organizational system. Alteration of the configuration of connections leads to variable values attached to system control parameters that drive subsequent system behaviors.

Control Parameter: Values attached to the five primary control parameters (rate of flows, strength of connections, density of connections, degree of diversity among system elements, and degree of influence differentials between system elements) that drive system behaviors. The composite effect of the parameters is a specific behavior that links the system to higher level holons (i.e., the external environment) and drives the system to either the stable zone, the complex zone, or chaotic zone. System behaviors that result from the parameters are assessed (as filtered through the cognitive schema of organizational members). This may lead to efforts to modify the deep structure of connections through a manipulation of the formal and/or informal control mechanisms to redirect subsequent system behaviors.

Cost function: In complex optimization problems, a cost function measures how good any particular solution is – the lower (or higher) the value of the function, the better the solution. In fitness landscape models, a cost function is referred to as a fitness function.

Deep structure: Deep structure is the particular and specific configuration or pattern of connections that link all members of the social system (organization) at any particular point in time. These multidimensional connections are composed the modes of interaction that characterize the dyadic relationship and the flows of exchange through those connections.

Deterministic chaos: Aperiodic bounded dynamics in a deterministic system with sensitive dependence on initial conditions (Kaplan and Glass, 1995). There are four basic features of chaos. Aperiodicity means that the same state is never repeated twice or that, in practice, cycle lengths are very long. Bounded means that on successive iterations the state of the system remains within a certain range of values. Deterministic means that there is a definite rule with no random or stochastic elements which governs system behavior. Sensitive dependence on initial conditions means that two points that are initially close together will diverge as system iterations proceed. Chaotic systems are often described in terms of strange attractors.

Developmental change: A change process (i.e., progression of change events) that unfolds in a gradual, continuous, incremental and self-sustaining manner. Developmental change processes allow the system to maintain its identity and continuity with its past in the face of a constant influx of new components, new strategies and responses to a changing environment.

Dispersive theory: Dispersive theories assume that relationships between phenomena are only loosely structured and not connected by underlying lawful relationships. The focus of a dispersive theory is on *description* of the behavior of the phenomena, as opposed to an explanation or account of the "causes" of that behavior. As Pepper (1942: 142-43) notes, for dispersive theories the universe consists "...of multitudes of facts rather loosely scattered about and not necessarily determining one another to any considerable degree." There is no underlying nomothetic structure to reality. Compare to integrative theories. See Tsoukas (1994).

Dissipative structures: An organized state of matter that arising beyond the first bifurcation point when a system is maintained far from thermodynamic equilibrium. "Dissipative structures have stable, recognizable forms that are continually being dissipated and renewed" (Stacey, 1996: 286).

Emergent property: A global (macro-level) property of a complex system that consists of many interacting (micro-level) elements. Emergent properties depend on the interacting behaviors of the individual elements but cannot be explained solely in terms of the elements themselves.

Entity: Any conceptual category of organizational activity (e.g., an individual's job, a class of jobs, a particular strategy), organizational characteristic (e.g., the organization's structure, form or strategy), or organizational membership (e.g., the individual, group, or overall organization).

Entropy: A quantity that determines a system's capacity to evolve irreversibly in time. Sometimes used to describe the degree of randomness or disorder in a system (i.e., a system in a state of maximum entropy is completely random and disordered).

Epigenesis: Development involving gradual diversification and differentiation of an initially undifferentiated entity. EPIGENETIC PROCESS

Epistasis: Epistatic coupling (or epistasis) refers to the idea that genes at other locations on the chromosomes affect the fitness contribution to the whole organism of any particular gene at a given place. Simply put, this means that the contribution of any particular element of the system to the entire system depends, not only on its own characteristics but also on the inputs (the K) from other elements (Kauffman, 1995: 170).

Ergodicity: The weakest and non-random version of "chaos" (Ford, 1983: 46; cf. "weak chaos," Bak *et al.*, 1991).

Equilibrium: In thermodynamics, the final state of time evolution at which all capacity for change is spent. Equilibrium thermodynamics is concerned with the properties of such states.

Exploitation learning: Improvement of system performance through a quantitative change in the strength of connections between system elements. That the fundamental structuring of interactions are not altered implies the notion of developmental change and morphostasis – a gradual and incremental process. Also implied is an emphasis on equilibrium maintenance and convergent processes.

Exploration learning: Improvement of system performance through a restructuring of connections between elements of the system. This may entail addition or removal of connections. Rather than a qualitative change, exploration suggests a qualitative in system structure and behavior. This implies a process of morphogenesis, transformational change and symmetry breaking. Also implied is an emphasis on nonequilibrium and divergent processes.

Feedback: A general term for the mechanism whereby the consequences of an ongoing process become factors (inputs) in modifying or changing that process. The original process is reinforced by positive feedback and suppressed by negative feedback.

Fitness landscape: A "map" representing the fitness measure or *cost function* of a problem. Variations in a cost function (or fitness function) can be visualized as a landscape of potential solutions where the height of each feature on the landscape is a measure of its cost. This rugged landscape is sometimes referred to as the *search space*.

Flows (exchange flows): Flows of exchange refer to the material and symbolic resources that move through the organizational system's interactional networks (modes of interaction). Such resources are of four types: instrumental/technical, power/authority, communication/information, affect/friendship.

Formism: One of Pepper's (1942) "world hypotheses." Formism is an approach to the generation of formal knowledge based on *analytic* and *dispersive* theories. From the formist perspective, phenomena are reducible to discrete components that are but loosely structured, not systematically connected by any underlying lawful relationships. Thus, "formistic knowledge claims seek to capture similarities between discrete objects of study without being necessarily concerned to offer an account of the underlying mechanisms that are responsible for any similarities and differences observed" (Tsoukas, 1994: 763). Formist knowledge relies on classification and categorization.

Gaia hypothesis: The proposal that the earth's living and nonliving components form an inseparable whole that is regulated and kept adapted for life by complex feedback mechanisms.

Generalized Exchange System (GES): The dominant mode of exchange in an interaction order where relationships between members are based on norms of unilateral and indirect reciprocity and where no immediate return is necessarily expected in any particular transaction between actors. A GES is characterized as collectivist, cooperative, homogenous and cohesiveness.

Genotype: The genetic constitution of an organism. For example, the genetic blueprint encoded in an organism's DNA that determines cell interactions.

GTYPE: The *generalized genotype* of a complex system. A system's GTYPE is that collection of low-level rules, laws and/or logic that link individual elements. The operation of those rules determine how elements interaction with each other and result in system behaviors (the system's PTYPE).

Gödel's theorem: Theorem in mathematical logic which states that it is impossible to reduce mathematics to a finite set of axioms and rules.

Heterarchy: Heterarchies are hierarchically arranged structures with multiple positive and negative feedback loops within and between levels of phenomena. Processes and events at one level affect processes and events at other levels. Heterarchies are non-decomposable and the holons that define the structure are non-separable.

Hierarchy: Structure where levels of phenomena are ordered around increasing levels of complexity and where one level is an aggregation of lower levels. Each level of phenomena can be explained and understood with reference to the sub-systems that compose the focal level. That is, a hierarchical system is partially decomposable and levels are fundamentally distinct and separate.

Holon: Fundamental components of heterarchical systems. Holons denote a concept similar to levels in a hierarchy, but holons is preferred because of the non-decomposability and non-separable structuring of a heterarchy. Each constituent holon has a dual tendency to preserve and assert its autonomy, while at the same time functioning as an integrated part of the larger whole. Because of this, a holon cannot be understood or explained without reference to the whole, and vice versa, the whole cannot be understood or explain without reference to its constituent holons. They comprise a non-separable and non-decomposable whole.

Integrative theory: As opposed to dispersive theories, an integrative theory holds that reality is well-ordered and structured according to underlying laws. As Pepper (1942: 142) notes, "...facts occur in a determinate order and where, if enough were known, they could be predicted, or at least described, as being necessarily just what they are to the minutest detail." Relationships between phenomena are fully describable and algorithmically compressible. A central focus of integrative theory is the discovery of these underlying, describable laws. Compare to dispersive theory. See Tsoukas (1994).

Interaction order: The concrete, repetitive activities and interactions that characterize the daily routine of a social setting – the informal system. An interaction order can be characterized as being dominated by a generalized exchange system (GES) or a restricted exchange system (RES).

Interactional processes: One of the three elements of Turner's (1988) theory of social interaction (see Appendix A). Interactional processes denote what actually occurs (what people do) when they influence each other's behavior. The analytical model of interactional processes provides an explanation for what actually happens during the dyadic exchange sequence.

Irreversibility: The one-way time evolution of a real system – gives rise to the arrow of time. The concept of the time irreversibility of a system is closely related to the second law of thermodynamics.

Isomorphism, Assumption of: The assumption of isomorphism suggests a total separation of levels where phenomena are fundamentally distinct, clearly bounded and isolated from other levels of phenomena as related to the causal mechanisms of dynamic processes. However, a link between the levels is posited whenever attributes at one level correlate (are isomorphic) to attributes at another level of phenomena.

Lamarckism: Theoretical approach to evolution holding that environmental changes evoked in individual organisms *direct adaptive responses* that could be passed on to their offspring as inheritable traits (acquired characteristics). In its earlier forms, it was referred to as *transformism* or *transmutation*. The Lamarckian theory of evolution was based on the operation of three biological laws: (1) environmental influence on organ development; (2) change in body structure based on use and disuse of parts; and, (3) the inheritance of acquired characteristics.

Levels of analysis: Used to refer to applied, empirical/methodological, theoretical and metatheoretical levels of analysis.

Levels of phenomena: Used to refer to the various levels (or holonic structure) of the phenomena or system of interest. Related to the notions expressed in hierarchy and heterarchy.

Limit cycle attractor: An attractor describing regular (periodic or quasi-periodic) temporal behavior of a system.

Lyapunov exponent: A measure of the strength of sensitive dependence on initial conditions of a deterministic equation. A principle characteristic of aperiodic trajectories is that, though bounded, each such trajectory deverges exponentially from any other. The Lyapunov exponent is the logarithm of the average separation or difference (the geometric mean) per iteration for a deterministic function and represents the rate at which the two trajectories diverge when they state close together..

Mechanism: An approach to obtaining formal knowledge based on *analytic* and *integrative* theories (Pepper, 1942). Reality is reducible to discrete components or elements and these components are linked by discoverable, nomothetic relationships. Tsoukas (1994: 765-766) notes six prominent features of a mechanistic approach: (1) objects of interest are ontologically given, fully describable, and algorithmically compressible; (2) the discrete elements of the object of interest are re-describable in some *quantitative* form which differs from common-sense perception; (3) there is a functional relationship between primary elements of the object, ideally a *lawful* relationship; (4) although the primary elements are quantitatively describable, there are *secondary qualities* which are characterized as background elements (Tsoukas notes that culture was such a secondary quality in the Aston studies); (5) secondary qualities are connected to the primary elements by some principle or lawful relationship which may be discovered when relationships between primary elements are known; and (6) relationships between primary qualities and elements are stable, therefore it is possible that secondary qualities exhibit stable relationships among themselves that are subject to *secondary laws*. See Tsoukas (1994).

Methodological individualism: The doctrine that macro-level phenomena are nothing more, nor less, than the simple aggregation of micro-level phenomena.

Mode of exchange: The characteristic mode of dyadic interaction that influences and conditions recurring exchanges among individuals. Such exchanges may proceed in a "restricted" manner (RES – restricted exchange system) or in a "generalized" manner (GES – generalized exchange system). The mode of exchange defines the system's interaction order. The predominant mode of exchange in the interaction order depends on, and is reflected in, the cognitive schema of organizational members.

Mode of interaction: The mode of interaction provides the contextual and situational categorization of a dyadic interactional episode. The setting for any particular interaction can be characterized as formal/prescribed, informal/social, or ceremonial/symbolic. Such categorization facilitates the interaction sequence by indicating the appropriate behaviors and responses due to (and from) each other in the interaction.

Morphogenesis: The evolution of form in living things. Second-order or transformational change. Morphogenesis refers to the emergence of new forms and structures. Morphogenic change occurs when the system's basic characteristics undergo multidimensional change and transformation and results in a fundamentally new mode of structuring and behavior.

Morphogenesis is equilibrium breaking, sudden, revolutionary and discontinuous.

Morphostasis: First-order or developmental change. Morphostasis refers to marginal change or incremental adaptation to changing circumstances *without* an accompanying change in the fundamental structuring and behavior of the system. Morphostatic processes serve to maintain system equilibrium, improve system efficiencies and effectiveness, and allow the system to remain on its current trajectory through phase space.

Motivational processes: One of the three elements of Turner's (1988) theory of social interaction (see Appendix A). Motivational processes explain how – to varying degrees and in diverse ways – individuals are energized and mobilized in interactions with others. Motivational processes provide an explanation for the impetus to interact with others.

Mutationism: After Mendel, it was discovered that inheritable changes in genes (i.e., mutations) could occur spontaneously and randomly without regard to the state of the environment. Since mutations were viewed as the only source of genetic novelty, many geneticists believed that evolution was driven by the *random accumulation* of favorable mutational changes. Natural selection (driven by competition for survival and directed by natural selection/adaptive fitness) was reduced to a minor role. Mutationism was predominant until the 1930s.

Natural selection: The process whereby gene frequencies in a population change through certain individuals producing more descendants than others because they are better able to survive and reproduce (they are more "fit") in a specific environment. Darwinian natural selection is based on the Malthusian notion that there are more individuals than environmental resources, leading to competition for survival. Those organisms which are most adapted (i.e., "best fit") are selected for survival while the less fit do not. Those organisms best suited pass on the characteristics/traits and this ensures survival of the population. When environmental change occurs, populations require new traits. Either the survival of a sufficient number of individuals with suitable traits leads to an eventual adaptation of the population (these traits are selected through the natural process of competition of scarce resources) or the population dies. Thus, according to Darwin, *evolution proceeds by the natural selection of well-adapted individuals over a span of many generations*. Natural selection is the process by which environmental effects lead to varying degrees of reproductive success among individuals of a population of organisms with different hereditary characteristics, or traits. The characteristics that inhibit reproductive success decrease in frequency from generation to generation. The resulting increase in the proportion of reproductively successful individuals usually enhances the adaptation of the population to its environment. Natural selection thus tends to promote adaptation by maintaining favorable adaptations in a constant environment (*stabilizing selection*) or improving adaptation in a direction appropriate to environmental change (*directional selection*). Thus, Darwinian theory holds that species of organisms arise and develop through the natural selection of inherited variations that increase the individual's ability to survive and reproduce.

Nonequilibrium: The state of a macroscopic system that has not attained thermodynamic equilibrium and still has the capacity to evolve in time.

Organicism: Approach to establishing formal knowledge based on *integrative* and *synthetic* theories. Organicism holds that the whole is more significant that the parts and that there is a lawful structure governing the behavior of the whole. As the integrated whole is of such ontological significance, organic approaches strive for comprehensiveness and an understanding of the (lawful) structure underlying the object of interest. See Tsoukas (1994).

Phenotype: The overall attributes of an organism resulting from the interaction of its genotype with the environment.

Population genetics: Based on the work of Theodosius Dobzhansky (*Genetics and the Origin of Species*), Darwinian natural selection processes were given mathematical and empirical support. His experimental work with fruit flies and controlled environmental manipulations demonstrated that adaptive genetic changes in large populations did occur. Thus, genetic inheritance of favorable traits was compatible with Darwinian natural selection, which is the chief cause of sustained changes in gene frequencies and therefore changes in a population's characteristics.

Process: The ordering and sequencing of events in an entity's or system's existence over time. A process involves descriptions and explanations of how events unfold, change, develop or transform over time.

Process theory: An explanation of how and why an entity or system changes its spatial characteristics and develops or transforms over time.

PTYPE: The *generalized phenotype* of a complex system. A system's PTYOE is that structure or behavior resulting from the functioning of rules, laws or logic that link system elements (the system's GTYPE).

Quantum mechanics: The mechanics that rule the microscopic world, when energy changes occur in abrupt, tiny quantum jumps.

Reductionism: A doctrine according to which complex phenomena can be explained in terms of simpler (constituent) constructs. In particular, reductionism contends that macroscopic system phenomena (behaviors and structures) can be explained in terms of properties of elements (or components) of the system. A reductionist position does not allow for emergent properties of macro-level systems.

Restricted Exchange System (RES): The dominant mode of exchange in an interaction order where relationships between members are based on norms of mutual reciprocity and where all members are motivated primarily by self-interest. The exchange relationship is viewed as a means to an end and as a contractual relationship (the contract may be either explicit or implicit). A RES is characterized by a high level of individualism, competition, impersonality, and contractualism.

Requisite Variety: The concept that increasing complexity and variety in the external environment requires greater variety of potential responses of a system, if it is to survive. That is, the variety in the external environment must be matched by a similar degree of internal variety to ensure that requisite responses to environmental contingencies are forthcoming. To survive in an increasingly complex and dynamic environment, a system must increase in internal complexity (i.e., become more differentiated internally) and flexibility in order to maintain its ability to adapt and respond.

Schema: A schema is a framework that models regularities in the stimuli experienced by a system. A schema consists of a set of rules that reflects regularities in experience and enables a system to determine the nature of further experience and make sense of it. A schema also contains rules indicating how a system should respond to its experience, which may include extending, modifying, or changing the rules comprising the schema. The rules in a schema are coded in the form of symbols, such as changes in electrical current, chemical interactions, mental images, and numbers that stand for some aspect of real experience. A schema is thus a symbol system.

Self-organization: The spontaneous emergence of nonequilibrium structural organization at a macro (system) level due to the collective interactions of a large number of micro-level elements.

Self-organized criticality: A generic pattern of self-organized nonequilibrium behavior in which there are long-range temporal and spatial regularities.

Sensitive dependence on initial conditions: One of the requirements for a system to exhibit chaotic behaviors. Small variations in initial conditions in nonlinear linear systems are amplified exponentially over time. Prediction of the behaviors of systems that are sensitive to initial conditions is problematic without exact knowledge and measurement of its parameter values.

Steady state: A nonequilibrium state that does not change with time.

Strange attractor: An attractor that has a fractal (fractional) dimension -- descriptive of the chaotic dynamics in dissipative dynamical systems.

Structuring processes: One of the three elements of Turner's (1988) theory of social interaction. Structuring processes provide an explanation of how dyadic social interactions are repeated across time (temporal dimension) and organized in physical space (spatial dimension). As such, the structuring process explains how the consistency of interaction (or lack thereof) is maintained and sustained over time.

Synthetic theory: Synthetic theories hold, in the Pepper (1942) framework, that the pattern or *gestalt* is the appropriate object of study, not any set of discrete elements or facts that are posited to comprise the object. A synthetic theory is *holistic* and suggests that it is the integrated whole that is of ontological significance, not any of its elements taken in isolation. Attempt at reductionist analysis fails to take into account emergent properties of the object of interest. Compare to analytic theories. See Tsoukas (1994). The term synthetic theory is also used to refer to the synthesis of Darwinian evolutionary theory and hereditary genetics.

System: A collection of spatially interrelated and temporally interacting entities.

Transformational change: A change process (i.e., progression of change events) that unfolds in a sudden, discontinuous, radical and revolutionary manner. Transformational change processes allow the system or entity to overcome the forces of inertia and stasis and break with its past.

Uncertainty principle: Heisenberg's uncertainty principle is a quantum mechanical principle that states it is meaningless to speak of a particle's position, momentum, and other parameters, except as a result of measurement. It places theoretical limits to the precision with which a particle's momentum and position can be measured simultaneously; the more accurately one is determined, the more uncertainty there is in the other.

APPENDIX C

TABLES

TABLE 1.1
Evaluative Criteria for Judging Theoretical Adequacy

CRITERION	*DESCRIPTION*
Comprehensiveness	The theory accounts for and incorporates all elements critical to an adequate explanation of the phenomena of interest.
Coherence	The internal structure of the theory should be logical. That is, the logic linking constructs and concepts to one another should be logically consistent and "fit" together.
Parsimony	The theory should rest on the least possible number of assumptions in attempting to explain the phenomena of interest. It should follow the philosophical "law of parsimony" or Ockham's razor.
Correspondence	There should be a close relationship between observable "facts" used to develop the theory and between implications derived from the theory and data collected to test the validity of those implications.
Pragmatism	The consequences following from the propositions and hypotheses of the theory should have some usefulness in application.

TABLE 2.1
Drivers and Directors of Organizational Dynamics

	Internal Driver	*External Driver*
Internal Director	*Driver*: Teleological processes of goal enactment and attainment or the dialectics of goal conflict. *Director*: Conscious decision of organizational members. *Change* occurs in proactive anticipation of any changes in the environment. *Examples*: Strategic Choice, Transaction Cost Economics	*Driver*: Conflicts between organizational and environmental contingencies. *Director*: Internally generated adaptations to changing environmental circumstances. *Change* occurs as an adaptive and reactive response to changing environmental circumstances. *Examples*: Coevolutionary, Rational Adaptation
External Director	*Driver*: Natural (and inescapable) progression of stages through which the organization develops. *Director*: Predetermined rules (or "laws") which guide the organization along the developmental path. *Change* is a consequence of natural processes or according to predetermined rules and/or laws. *Examples*: Life-Cycle Theories, Stage Theories	*Driver*: Competition for scarce resources between members of a population or populations of organizational forms. *Director*: Selection mechanisms operating at the population level. *Change* occurs as a result of natural processes entirely external to the organization. *Examples*: Selection Theories, Ecological Theories

TABLE 2.2
Drivers and Directors:
Implications for Management

	Internal Driver	*External Driver*
Internal Director	Managers have complete control over the direction and provide the driving force for organizational change. Therefore, the task for management is to actively manage both the internal and external environments.	Managers can control the direction of changes in internal arrangements, but the forces for change lie outside the organization. Therefore, the task for management is to recognize the externally driven need for change and to structure internal arrangements to align the organization with external contingencies.
External Director	Managers can provide the impetus for internal change, but once begun internal change processes move through an inevitable (and inescapable) series of stages. The task for management is to recognize and understand the operative stage of the organizational life-cycle and to take actions based on the imperatives of that stage. Though the natural laws determining organizational progression are internal to the organizational system, they are outside the control of organizational members.	Managers have no control over either the impetus or the direction of change processes. Both driver and director of change is external to the organization. Management plays no role whatsoever in the dynamic processes of organizational change.

TABLE 2.3
Modalities of Change

Author	*Morphostasis*	*Morphogenesis*
Argyris & Schon (1978: 2-3), Learning theory.	**Single loop learning**: "...permits the organization to carry out its present policies or achieve its present objectives"	**Double loop learning**: "...involves the modification of an organization's underlying norms, policies, and objectives"
Kindler (1979: 478), Planned change.	**Incremental change**: "... step by step movement or variations in degree along an established conceptual continuum or system framework...it is intended to do more of the same but better"	**Transformational change**: "...is a variation in kind that involves reconceptualization and discontinuity from the initial system"
Miller & Friesen (1982: 592), Organization theory.	**Momentum change**: "...momentum is expected to be a dominant factor in organizational evolution...reversals in the direction of change in strategy and structure are expected to be rare"	**Revolution change**: "Organizational adaptation is also likely to be characterized by periods of dramatic revolution in which there are reversals in the direction of change across significantly larger numbers of variables of strategy and structure"
Sheldon (1980: 64), Management.	**Normal change**: "The fit between the organization and its environment and among its components is so rarely perfect, so...organizations are constantly tinkering with one dimension or another"	**Paradigm change**: "...involves several or all dimensions at once...radical change in the world and world view"
Carneiro (1981: 179), Neo-evolutionary theory.	**Growth**: "...is usually manifested by growth of structures already present and is essentially quantitative...growth tends to be continuous"	**Development**: "...is characterized by the emergence of new structural forms and is essentially qualitative...development is generally discontinuous and proceeds by a series of jumps"
Ramaprasad (1982: 387-388), Management theory.	**Mind change**: "...merely improving the efficiency of current operations"	**Revolutionary change**: "...redefines the system. The redefinition may be entirely conceptual, structural, or processual, or a combination of the three"
Davis (1982: 65), Management.	**Change**: "...a shift in the content of anything referred to herein as change"	**Transformation**: "...a shift of the context will be referred to as transformation"
Fombrun (1986:404,409), Organization theory.	**Convergence**: "... a process...through which organizations establish order, achieve stability, and maintain themselves in a state of homeostatic equilibrium...structures are institutionalized in an incremental fashion, change is evolutionary, and organizations develop over time"	**Divergence**: "...forces provoking contradiction that tends to propel episodic, punctuational, and metamorphic transformations in the social relations within and between organization"
Van de Ven and Poole (1995:522), Organization theory.	**Prescribed change**: "A *prescribed* mode of change channels the development of entities in a prespecified direction, typically of maintaining and incrementally adapting their forms in a stable, predictable way"	**Constructive change**: "A *constructive* mode of change generates unprecedented, novel forms that, in retrospect, often are discontinuous and unpredictable departures from the past"

Adapted from Leifer (1989), Levy and Merry (1986).

TABLE 3.1
Selected Approaches to the Study of Complex Systems

Perspective	***Spatial Characteristics***	***Temporal Behaviors***	***Discipline***
Dissipative Structures	Many simple elements	Discontinuous	Chemistry
Chaos	Simple	Complex and Discontinuous	Meteorology Physics Mathematics
Complexity	Complex	Simple or Complex, Continuous or Emergent Order	Biology Chemistry
Self-Organized Criticality	Complex	Complex and Discontinuous	Physics
Catastrophe	Complex, but reduced	Complex and Discontinuous	Topological Analysis Mathematics

TABLE 3.2
Why Study Complexity?

Reason	***Justification***
Increasing Rates of Change	Increasing rates of environmental change require more flexible and adaptive organizational structures and forms. The complexity sciences seek to understand how and why systems change, respond and adapt. The complexity sciences promise lead to a better understanding of organizational processes and the mechanisms of social change.
Emphasis on Process Research	An incorporation of a complexity approach to understanding the dynamic *temporal* properties of systems is consistent with an increasing emphasis on process research in the organizational sciences.
Similarity to Existing Models	At the level of methodology and empirical analysis, the models and methods utilized in the complexity sciences are not completely unrelated to those already in use in the organizational sciences. Complexity methods may provide significant extensions to existing methodologies.
Disappointing Results and Lack of Relevance	Current approaches to the study of the processes and mechanisms are limited and have little to offer – in the way of results – to either researcher or practitioner. The complexity sciences offer the potential to improve the results obtained by researchers and increase the relevance of those results to practitioners.
Metatheoretical Assumptions	The complexity sciences – as an approach to the study of system dynamics – are grounded in fundamentally different metatheoretical assumptions from the classical Newtonian and Darwinian paradigm. This alternate metatheory promises the potential for an significant reconceptualization of the processes and mechanisms of social and organizational dynamics.

TABLE 4.1
Greek Philosophy and Change

	Heraclitus (*circa* 530 to 470 BCE)	***Parmenides*** (*circa* 515 to 450 BCE)	***Plato*** (*circa* 427 to 347 BCE)	***Aristotle*** (*circa* 384 to 322 BCE)
Existence of change	Constant change alone is reality. Stability is an illusion.	Reality is stable, permanent. Change is only appearance and is logically impossible.	Change exists, but only in the lower realm of corporeal restlessness, not in the stable, transcendent realm.	Change exists, but is only a manifestation of the temporal world.
Cause of change	Doctrine of the opposites, in which opposing phases of equal status alternate.	Sense perception, illusion.	The cerebral quest for abstract ideals in the upper realm.	An attempt to gain what is lacking through actualization of potential.
Is change good?	Yes: the conflict implied by change guards against the stagnation of a harmonious world.	No.	No: the world of change is one of degeneration and decay.	No: change means one is lacking in some respect.
Does change have a purpose?	No.	No.	Yes: reaching the transcendent nature of pure form.	Yes: the final cause, realization of one's potential through moral conduct.
Management of change	Believe only in change. Accept that change is due to chance and necessity. It is purposeless, meaningless, and unmanageable.	Believe only what is stable, which is discovered through use of reason and logic. Managing change is irrelevant, because change is illusory.	Emphasize stable ideas/forms. Disciplined use of the intellect gives one control over chaos. Only a few superior individuals will succeed in reaching the changeless world, and they should make decisions for the others.	Emphasize stable ideas/forms. Through reason, contemplation, and observation all people should discover and achieve ideas (i.e., actualize potential). Give change meaning by directing it toward an ultimate goal.
Implications	Since change is ***unavoidable*** and ***unpredictable***, planning is irrelevant.	Focus efforts on maintaining stability and the ***status quo***. Plan for continuity with past experience.	Planning for change should be the domain of the select few, the leaders of the organization.	Planning should involve all members of the organization.

Adapted from Wagner (1995).

TABLE 4.2
Framework for the Development of Systems Thinking

	Prigogine and Stengers	*Jantsch*
Stage	*Characteristics/Assumptions*	
One	Steady/Equilibrium State	Deterministic Assumptions
Two	Dynamic Equilibrium	Equilibrium Assumptions
Three	System Instability/Disequilibrium	Dissipative Structures

TABLE 4.3
Assumptions and Corollaries of Stages One and Two

Assumption 1:	*Systems "seek" to maintain a state of equilibrium.*
Corollary 1.1:	*Unless subject to abnormal pressures, such systems remain in equilibrium.*
Corollary 1.2:	*In a closed system, the result is a static equilibrium state of maximum entropy – a movement toward disorder, lack of resource transformation and, eventually, death and disintegration.*
Corollary 1.3:	*Open systems are able to maintain a state of dynamic equilibrium or homeostasis through the importation of negative entropy (a continuous inflow of materials, energy and information).*
Corollary 1.4:	*Forces and pressures for change are normally externally generated. Internal forces and pressures that disrupt equilibrium are viewed as dysfunctional and abnormal.*
Assumption 2:	*System behavior is typically directed by self-maintaining, negative feedback.*
Corollary 2.1:	*Self-correcting negative feedback loops are the major mechanisms of equilibrium maintenance. Negative feedback provides information to the system about deviations from an equilibrium state. Thus, negative feedback serves to maintain the essential character of the system*
Corollary 2.2:	*Positive feedback loops are deviation amplifying, destabilizing and disruptive to system behavior.*
Assumption 3:	*System elements are hierarchically arranged into subsystems that are, in turn, hierarchically arranged to form the total system. Elements and subsystems are discrete and (at least analytically) decomposable.*
Corollary 3.1:	*Boundaries between the constituent elements of a system and its subsystems are clear and distinguishable.*
Corollary 3.2:	*Boundaries between the system of interest and its environment are clear and distinguishable.*
Assumption 4:	*Linkages between system components (elements) and between the system and its environment are linear.*
Corollary 4.1:	*There is a clear distinction between "cause" and "effect."*
Corollary 4.2:	*Relationships between cause and effect are consistent and proportional.*

TABLE 4.4
Implications of Stage One and Two

Implication 1:	*Small changes in system parameters result in small, or incremental, changes in system behaviors.* (Underlying principle: system stability from Assumptions 1, 2 and 4).
Implication 2:	*A completely deterministic system results in behavior that is completely deterministic and ultimately predictable.* (Underlying principle: proportionality and clear distinction between cause and effect from Assumption 4).
Implication 3:	*The best (only) method of understanding complex systems is to break them into smaller, more manageable parts. As the individual elements are understood, the elements can be reconstituted and combined to understand overall system behavior.* (Underlying principle: reductionism from Assumption 3).
Implication 4:	*Unexpected system behaviors result only from complicated, hard-to-understand interactions among a system's internal components, or from an outside perturbation.* (Underlying principle: determinism from Assumptions 2, 3 and 4).
Implication 5:	*System instabilities are inherently negative and dysfunctional. Efficient and effective system functioning requires that instabilities be dampened and/or controlled to minimize their negative effects.*

TABLE 5.1
Comparison of Stage One, Two and Three Assumptions

	Equilibrium	*Feedback*	*Hierarchical Structuring*	*Linearity*
Stage One	Static, steady state equilibrium between internal components.	Not explicitly considered.	Decomposable into component elements.	Closed, linear relationship between internal components.
Stage Two	Dynamic equilibrium between internal and external components.	Emphasis on the benefits of negative feedback mechanisms for maintaining equilibrium. Positive feedback viewed as destabilizing.	Nearly decomposable.	Linear relationships between internal and external components.
Stage Three	Periodic fluctuations and bifurcations.	Emphasis on the beneficial operation of positive feedback in system change and development.	Non-decomposable. Systems are holistic entities and components are non-separable.	Non-linear relationships between internal and external components.

TABLE 5.2
Implications of the Stage Three Complexity Approach

Complexity Implication 1	*Small changes in system parameters may result in large, nonproportional, or discontinuous changes in system behaviors.*
Complexity Implication 2:	*A completely deterministic system can result in behavior that, while completely deterministic, is inherently unpredictable.*
Complexity Implication 3:	*Complex composite systems cannot be understood through a reductionist strategy of examining individual elements or levels of phenomena in isolation, then recombining those partial explanations into a description of overall system behaviors. Such systems can only be understood holistically.*
Complexity Implication 4:	*Unexpected system behaviors may be examples of emergent properties of systems whose elements and internal interactions are well-understood and completely specified.*
Complexity Implication 5:	*Periodic instability is neither dysfunctional nor negative. Rather, such periodic fluctuations are necessary for the explanation of morphogenic processes and transformational changes in system behaviors and structures.*

TABLE 5.3
Elementary Catastrophes

Catastrophe	*Control Dimensions*	*Behavior Dimensions*	*Function*	*First Derivative*
Fold (cuspoid)	1	1	$1/3x^3 - ax$	$x^2 - a$
Cusp (cuspoid)	2	1	$1/4x^4 - ax - 1/2bx^2$	$x^3 - a - bx$
Swallowtail (cuspoid)	3	1	$1/5x^5 - ax - 1/2bx^2 - 1/3cx^3$	$x^4 - a - bx - cx^2$
Butterfly (cuspoid)	4	1	$1/6x^6 - ax - 1/2bx^2 - 1/3cx^3 - 1/4dx^4$	$x^5 - a - bx - cx^2 - dx^3$
Hyperbolic (umbilic)	3	2	$x^3 + y^3 + ax + by + cxy$	$3x^2 + a + cy$ $3y^2 + b + cx$
Elliptic (umbilic)	3	2	$x^3 - xy^2 + ax + by + cx^2 + cy^2$	$3x^2 - y^2 + a + 2cx$ $-2xy + b + 2cy$
Parabolic (umbilic)	4	2	$x^2y + y^4 + ax + by + cx^2 + dy^2$	$2xy + a + 2cx$ $x^2 + 4y^3 + b + 2dy$

Thom's seven elementary catastrophes describe all possible discontinuities in phenomena controlled by no more than four factors. Each of the catastrophes is associated with a potential function in which the control parameters are represented as coefficients (a, b, c, d) and the behavior of the system is determined by the variables (x, y). The behavior surface in each catastrophe model is the graph of all the points where the first derivative of this function is equal to zero or, when there are two first derivatives, where both are equal to zero. (Zeeman, 1976: 78; Thom, 1969; Oliva, DeSarbo, Day and Jedidi, 1987).

TABLE 5.4
BASIC Program for the Logistic Difference Model
Bifurcation Diagram (Figure 5.3)

```
10    CLS
20    CLEAR : KEY OFF:  DEFINT G, J:  SCREEN 12
30    PRINT "LOGISTIC DIFFERENCE CURVE – BIFURCATION DIAGRAM"
40    PRINT "For Number of Iterations, Beginning, Ending = ";
50    INPUT iter, start, stopp
60    dif = (stopp – start) : pix = dif / 638
70    VIEW (1, 40) – (638, 448),  ,1
80    WINDOW (start, 0) – (stopp, 1)
90    IF dif >= .1 THEN GOSUB 200
100   FOR k = start TO stopp STEP pix
110   x = .5
120   FOR j = 1 TO iter
130   x = k * x * (1 – x)
140   PSET (k, x), 4 : NEXT j, k : END
200   FOR k = 0 TO 4 STEP .25 : LINE (k, 0) – (k, 1) : NEXT k : RETURN
```

TABLE 5.5
Differences between Chaos Theory and SOC

Chaos Theory	***Self-Organized Criticality***
The effects of small initial uncertainties increase *exponentially* over time. This suggests a sensitive dependence on initial conditions where an exact specification of initial conditions is critical to subsequent system behavior.	Uncertainties increase according to a *power law distribution*, rather than increasing exponentially. Initial conditions are not critical to the explanation of subsequent system behaviors.
Exponential growth in the effects of initial uncertainties results in *strong chaos* and prevents long-term prediction of system behaviors.	Distribution of events in a system's history according to a simple power law results in *weak chaos* where some measure of predictability is possible.

TABLE 5.6
Emergent Behaviors in Self-Organizing Systems

Regime of Behavior	***Characteristics***
Ordered Regime	In the ordered regime, elements of the system freeze into a fixed state of activity. Change does not occur in this regime of the network of elements unless acted upon by exogenous forces.
Chaotic Regime	In the chaotic regime, a cluster of connected elements fluctuate in complex ways. Change is endogenously generated and propagated. Behavior in the chaotic regime is sensitive to initial conditions.
Complex Regime	The complex regime is a phase transition between frozen order and chaotic fluctuation (at the edge of chaos). Systems (or networks of elements) in the transition regime can perform the most complicated tasks – this complexity can overcome both the inertia of the stable/frozen regime and the instability of the chaotic regime. Systems in the complex regime can exhibit spontaneous, emergent, and autocatalytic organization. Such complex self-organizing behaviors are the result of the system of complex interactions among elements, not the result of any individual element in the system.

TABLE 5.7
Cybernetic, Open, and Complex Adaptive Systems

	Cybernetic	***Open***	***Complex Adaptive***
Driver	External environmental criteria	Internal conversion and transformation processes	Control parameters determined by interactions (PTYPE)
Director	Internal goal-seeking mechanisms	External environmental fluctuations	Control mechanisms – rules and logic governing interactions between elements (GTYPE or schema)
Control	Negative feedback loops	Boundary spanning activities	Interaction between control mechanisms and control parameters.
Level of Predictability	High	Moderate	Variable – • High in frozen regime • Moderate in complex regime • Low in chaotic regime
Change Mode	Reactive morphostasis	Adaptive morphostasis	Morphostatic and morphogenic processes
Characteristic	Need for differentiation (requisite variety). Stability, consistency and equilibrium maintenance between system and environment.	Differentiation and integration. Dynamic equilibrium between internal elements *and* between internal subsystems and external environment.	Differentiation and integration, but the system exhibits both periods of dynamic equilibrium and periodic bifurcations, transformations and catastrophes.
Hierarchical structuring	Theoretically and analytically decomposable.	Near decomposability.	Non-decomposable.

TABLE 5.8
Control Parameters of CAS

Parameter	***Description***
Rate of Flows	The rate of flows of resources, energy and information through the system is the primary link between system and environment. Three components of the rate of flows are significant: the absolute rate of flows, the absolute rate of flows in the environment, and the relative rates of flows between those of the system and those in the environment.
Density of Connections	CAS are sensitive to the degree of connectivity between system elements. Less density tends to result in stable, networks (efficient) but such systems are prone to stasis and inertia. More density (i.e., greater connectivity) results in flexible, adaptive (effective) networks and greater rates of flow, but densely connected networks are prone to chaos and instability.
Strength of Connections	Strong connections tend to canalyze flows resulting in stable, frozen networks that exhibit stability and reliability of performance but that are not very responsive to environmental contingencies. Weakly connected networks are responsive and adaptable (effectiveness), but are prone to instability and redundancies.
Influence Differentials	Low influence differentials (all elements have similar degrees of influence) tend to result in systems exhibiting more responsiveness and flexibility, but that are prone to instability and chaos. High degrees of influence differential (a few "influential" elements) tend toward stability and reliability. Very influential elements tend to attract flows from other elements and tend to canalyze flows through the system. Such systems are more hierarchical and stable, but may be prone to stasis and inertia.
Degree of Diversity	A system with identical elements, though generally more stable and efficient, may not exhibit the requisite variety required for adequate response to environmental pressures, thus leading to stasis and inertia. High degrees of diversity increase the requisite variety and respond more effectively to environmental pressures, but may push the system toward instability and chaos.

TABLE 6.1
The Regulation—Radical Change Dimension

The sociology of REGULATION <u>is concerned with</u>:	*The sociology of RADICAL CHANGE <u>is concerned with</u>:*
The status quo	Radical change
Social order	Structural conflict
Consensus	Modes of domination
Social integration and cohesion	Contradiction
Solidarity	Emancipation
Need satisfaction	Deprivation
Actuality	Potentiality
Stability	Change
Integration	Conflict
Functional coordination	Disintegration
Consensus	Coercion

Source: Burrell and Morgan (1979: 13, 18).

TABLE 6.2
Traditional versus Complexity Implications

Traditional Implications *(Stage One and Two)*	***Complexity Implications*** *(Stage Three)*
Small changes in system parameters result in small, proportional, or incremental, changes in system behaviors.	Small changes in system parameters may result in large, nonproportional, or discontinuous changes in system behaviors.
A completely deterministic system results in behavior that is completely deterministic and ultimately predictable.	A completely deterministic system can result in behavior that, while completely deterministic, is inherently unpredictable.
The best (only) method of understanding complex system is to break them into smaller, more manageable parts. As individual elements are understood, the elements can be reconstituted and combined to understand overall system behavior.	Complex composite systems cannot be understood through a reductionist strategy of examining individual elements or levels of phenomena in isolation, then recombining those partial explanations into a description of overall system behaviors. Such systems can only be understood holistically.
Unexpected system behaviors result only from complicated, hard-to-understand interactions among a system's internal components, or from an outside perturbation.	Unexpected system behaviors may be examples of emergent properties of systems whose elements and internal interactions are well-understood and completely specified.
System instabilities are dysfunctional. Efficient and effective system functioning requires that instabilities be dampened and/or controlled to minimize their negative effects.	Periodic instability is neither dysfunctional nor negative. Rather, such periodic fluctuations are necessary for the explanation of morphogenic processes and transformational changes in system behaviors and structures.

TABLE 7.1
Assumptions, Definitions and Propositions

Assumption 7.1:	The basic elements of a social system are individuals.
Assumption 7.2:	The fundamental mechanism through which the dynamics of social systems occur is the interaction and exchange between individual members.
Assumption 7.3:	Interactions within social systems are open to external (i.e., environmental) influences. That is, social systems fall into the class of open systems.
Assumption 7.4:	Structural arrangements in social systems derive from the spatial and temporal patterns of interaction and exchange that connect individual members of the system.
Definition 7.1:	A social system is a relatively dense collection of dyadic interactions where individuals are connected to each other according to some logic, set of rules or laws. This logic defines and delimits the appropriate means, modes and methods of interaction and exchange in the dyadic relationship.
Proposition 7.1:	Because (1) the basic elements of social systems are individuals and (2) the dynamics and structuring of social system behaviors result primarily from the interactions and exchanges among those members, the fundamental unit of analysis is the connection between individuals.
Proposition 7.2:	Organizational structure results from (1) formal macro-level configurations (prescribed interactions), (2) informal micro-level configurations (interaction order), and (3) the interplay between the objective attributes of that structure and the socially constructed, subjective interpretations of those attributes.
Definition 7.2:	*Deep structure* is that specific configuration or pattern of connections – interactions and exchanges – that links all members of the organizational system at any particular point in time.
Definition 7.3:	Connections are conceptualized as composed of two elements: modes of interaction and flows of exchanges.

Table 7.1, cont.

Definition 7.4:	The formal or prescribed mode of interaction is that mode of interacting that reflects the organizationally defined and designated aspects of any interaction episode.
Definition 7.5:	The informal or social mode of interaction is that mode of interacting that arises through the day-to-day interactions among actors in the organizational system.
Definition 7.6:	The ceremonial or symbolic mode of interaction is that mode of interacting that reflects the cultural and deferential aspects of interaction episodes.
Definition 7.7:	Flows in an organization refer to *what* is exchanged in any interactional sequence (i.e., the content of the exchange).
Definition 7.8:	Flows of exchanges are either: (1) instrumental or technical flows; (2) power or authority flows; (3) communication and information flows; (4) affect or friendship flows.
Assumption 7.5:	Connections between individuals are regulated by a complex set of logic, rules and laws governing their interactions. These are reflected, and find expression, in the cause-and-effect schema utilized by individual members.
Proposition 7.3:	Organizational control over the deep structure of connections is greatest for 1st order formal mechanisms. Progressively less degree of control is exerted over 2nd and 3rd mechanisms.
Proposition 7.4:	Choice of formal mechanism to emphasize in efforts to control and align the organizational deep structure is dependent on the dominant organizational level schema.
Proposition 7.5:	The joint effect of many recurring dyadic interactions in an organizational setting is the emergence of a dominant mode of exchange. This mode of exchange characterizes the interaction order of the organizational system and provides the primary informal control mechanism linking micro-level dyadic processes to macro-level organizational processes.
Proposition 7.6:	The operative informal control mechanisms of an

Table 7.1, cont.

	organizational system depend on the interaction order (either RES or GES) that emerges out of day-to-day, recurring exchange interactions among organizational members. This interaction order is reflected in and constituted by individual level schema.
Proposition 7.7:	The dynamic behaviors of complex social systems result from the interplay between the objective control parameters that drive system behaviors and the subjective control mechanisms that direct system behaviors.
Proposition 7.8:	Rates of flows link the deep structure of a complex system through both the effectiveness of resource flows and the efficiency of relative rates of flow.
Proposition 7.9.1:	Organizations that rely primarily on 1st order formal control mechanisms will tend to exhibit less density, or connectivity, than organizations relying on 2nd and 3rd order mechanisms.
Proposition 7.9.2:	Mechanistic organizations rely on 1st order formal control mechanisms to directly influence the deep structure of connections in order to enhance stability and efficiency.
Proposition 7.9.3:	Organic organizations rely on 2nd and 3rd order formal control mechanisms to indirectly influence (through informal control mechanisms) the deep structure of connections in order to enhance flexibility and effectiveness.
Proposition 7.10.1:	An organization with an interaction order (i.e., informal control mechanism) characterized by restricted modes of exchange (RES) will exhibit a low degree of connectivity and density.
Proposition 7.10.2:	An organization with an interaction order (i.e., informal control mechanism) characterized by a generalized exchange mode (GES) will exhibit a high degree of connectivity and density.
Proposition 7.11.1:	An organization with an interaction order (i.e., informal control mechanism) characterized by a restricted exchange mode (RES) will have a preponderance of weak connections.

Table 7.1, cont.

Proposition 7.11.2:	An organization with an interaction order (i.e., informal control mechanism) characterized by a generalized exchange mode (GES) will have a preponderance of strong connections.
Proposition 7.12.1:	An increase in the degree of diversity of abilities, perspectives and contributions of individual members tends to increase the potential for flexibility and adaptability in the deep structure of connections. A decrease in the diversity of abilities, perspectives and contributions of individual members tends to increase potential for stability and reliability in the deep structure of connections.
Proposition 7.12.2:	An increase in the degree of diversity of abilities, perspectives and contributions of individual members tends to increase the potential for instability and variability in the deep structure of connections. A decrease in the diversity of abilities, perspectives and contributions of individual members tends to increase the potential for stasis and inertia in the deep structure of connections.
Proposition 7.13.1:	An increase in the differential degrees of influence, power and authority will tend to increase the potential for stable and reliable system behavior. A decrease in influence differentials will tend to increase the potential for flexible and adaptive system behavior.
Proposition 7.13.2:	An increase in the differential degrees of influence, power and authority will tend to increase the potential for stasis and inert system behavior. A decrease in influence differentials will tend to increase the potential for unstable and chaotic system behavior.

TABLE 8.1
Developmental and Transformational Phases

	Phase One	*Phase Two*	*Phase Three*
Definition	Formative period	Developmental period	Transformational period
Critical Issue	*Establishing* equilibrium conditions in absolute and relative rates of flows	*Maintaining* equilibrium conditions in absolute and relative rates of flows	*Restoring* equilibrium conditions in absolute and relative rates of flows
Learning Mode	Exploration	Exploitation	Exploration
Connections	Low canalization, but converging dynamics (increasing equilibrium conditions)	High canalization, convergence but diverging dynamics (increasing disequilibrium conditions). Reliance on increasing efficiency and effectiveness of buffering and dampening mechanisms established in Phase I	High canalization, but disequilibrium conditions in rates of flows leads to a period of divergence and point of singularity (bifurcation). Transformational change or organizational decline
Success Criteria	Effectiveness criteria valued over efficiency	Efficiency criteria valued over effectiveness	Flexibility, responsiveness, adaptability

TABLE 8.2
Functional Modes for Strategic Direction

Mode	**Strategic Planning**	**Strategic Management**	**Strategic Learning**
Primary emphasis	Emphasis on *product* – the generation of a strategic plan that maps the long-term direction for the organization	Emphasis on *process* – the identification and analysis of critical internal and external factors that can affect the long-term direction of the organization	Emphasis on *emergence* – the long-term direction is established through a process of logical incrementalism and continuous learning
Primary Focus	Implementation and control	Setting objectives; Crafting and formulating strategies	Providing overall sense of direction and mission
Success criteria	Efficiency	Effectiveness	Adaptability and flexibility
Potential for prediction and control	Prediction and control is possible in a deterministic sense.	Prediction and control is possible is a probabilistic sense.	Inherently indeterminate (for long-term behaviors).
Relationship between the organizational system and the environment	Organization and environment as separate and distinct entities	Distinct and separable levels, but closely linked and interacting entities	Nonseparable, environment and organizational system form a unified whole
Theoretical perspective	Cybernetic systems	Open Systems	Complex Adaptive Systems
Metatheoretical foundations	Stage One	Stage Two	Stage Three

TABLE 8.3
Research Methods and Results

	Quantitative Methods	***Qualitative Methods***	***Simulation Methods***
Precision	High	Moderate	Variable[3]
Realism	Low[1]	High	Variable[3]
Generalizability	Moderate	Low[2]	Variable[3]

1. Quantitative methods, while highly precise and moderately generalizable, are low on realism because of a reliance on reduced-form models.
2. Qualitative methods, while moderately (though not necessarily quantitative and measurable) and highly realistic, are low on generalizability because of the depth of contextual and situational detail included in the analysis.
3. Simulation methods, depending on the specific approach, can emphasize any two of the criteria at the expense of one. For example, the simulation model developed by Koput (1997) sacrifices realism for precision and generalizability (quantitative simulation). The loop-analysis approach of Puccia and Levins (1985) sacrifices precision and measurability for realism and generalizability (qualitative simulation).

TABLE 8.4
Typology of Quantitative Models

Type	*Description*	*Constraints*	*Examples*
Zero	Constant state model. A Type Zero model has no dynamics, strictly speaking, and its state remains unchanged.	Absolute	Images, gravity models, structures
I	Solvable dynamic systems. Type I systems are differential equations that are mathematically solvable.	Analytic integrals	Gear trains, 2-body problem, physical pendulum
II	Systems that are amenable to perturbation theory. Type II models can be solved through use of perturbation techniques.	Approximate analytic integrals	Satellite orbits, lunar and planetary equations
III	Systems having chaotic solutions. Type III models are chaotic deterministic systems.	Quasi-deterministic; smooth and bounded, but erratic, trajectory	Climatology models, Lorenz equations, logistic equation
IV	"Random" systems. Type IV models are rigorously defined only by averages over time and space.	Turbulent, stochastic, probabilistic	Quantum mechanics, turbulent flow, statistical mechanics, roulette wheel (one-dimensional example)

Source: Morrison (1991: 168).

TABLE A.1
Propositions from Turner's Dynamic Theory

Proposition A.1:	The structuring of interaction depends on the stabilization of resource transfers across time.
Proposition A.2:	The structuring of interaction depends on the ability of each actor to realize some profit.
Proposition A.3:	The structuring of interaction depends on the assessment of each individual actor that the exchange is fair and just with regard to relevant norms.
Proposition A.4:	The structuring of social interactions revolves around resource transfers, especially with respect to issues of group membership.
Proposition A.5:	As resource transfers are stabilized through established ratios of payoffs and rituals, they become more structured, making it easier to link encounters together in chains of interaction.
Proposition A.6:	The categorization or classification of situations (work/practical, social, ceremonial) facilitates structuring by indicating what emotional and cultural resources are relevant to a conversational exchange and what rituals are most appropriate for such exchanges.
Proposition A.7:	The particular categories and resources to be employed in an encounter is circumscribed by demographic/ecological conditions, especially the number and distribution of actors in time and space.
Proposition A.8:	Social structure will be sustained to the extent that it enables individuals to maintain positive self evaluations about those dimensions of their self that they see as important.
Proposition A.9:	Individuals orient themselves to situations in terms of common cognitions. That is, in defining social interactions, individuals tend to look for commonalities with others in defining a particular situation.

Table A.1, cont.

Proposition A.10:	Those interactions that can be ordered in space/time and that can be sequenced in a predictable (ritual) form will be more readily repeated and linked together in chains of interaction.
Proposition A.11:	As individuals in a society acquire knowledge about what physical props, spacing, staging, and behavioral sequences "mean" in varying contexts (the interaction is regionalized), they can organize their responses without great interpersonal effort.
Proposition A.12:	There is a normative element to social interaction and those norms are malleable tools for ordering interaction.
Proposition A.13:	Routines and routinization, which increase predictability and the habitual nature of individual responses, promotes the structuring of interaction across time.
Proposition A.14:	Regionalization, which orders actors in space, increases the ability to maintain the interaction across time.

APPENDIX D

FIGURES

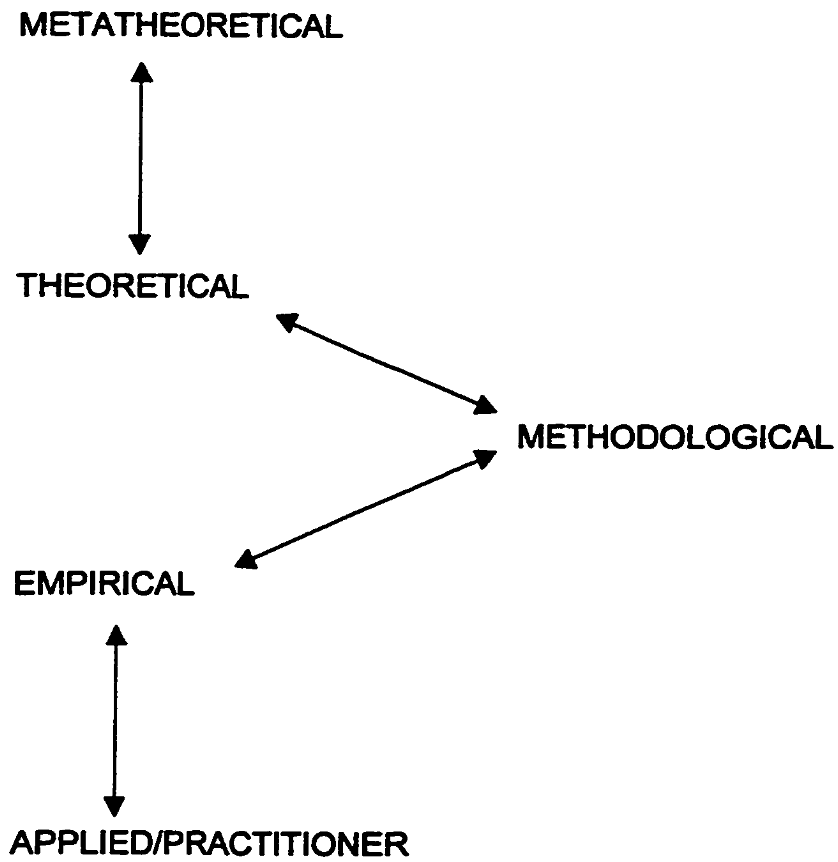


FIGURE 1.1: Levels of Analysis

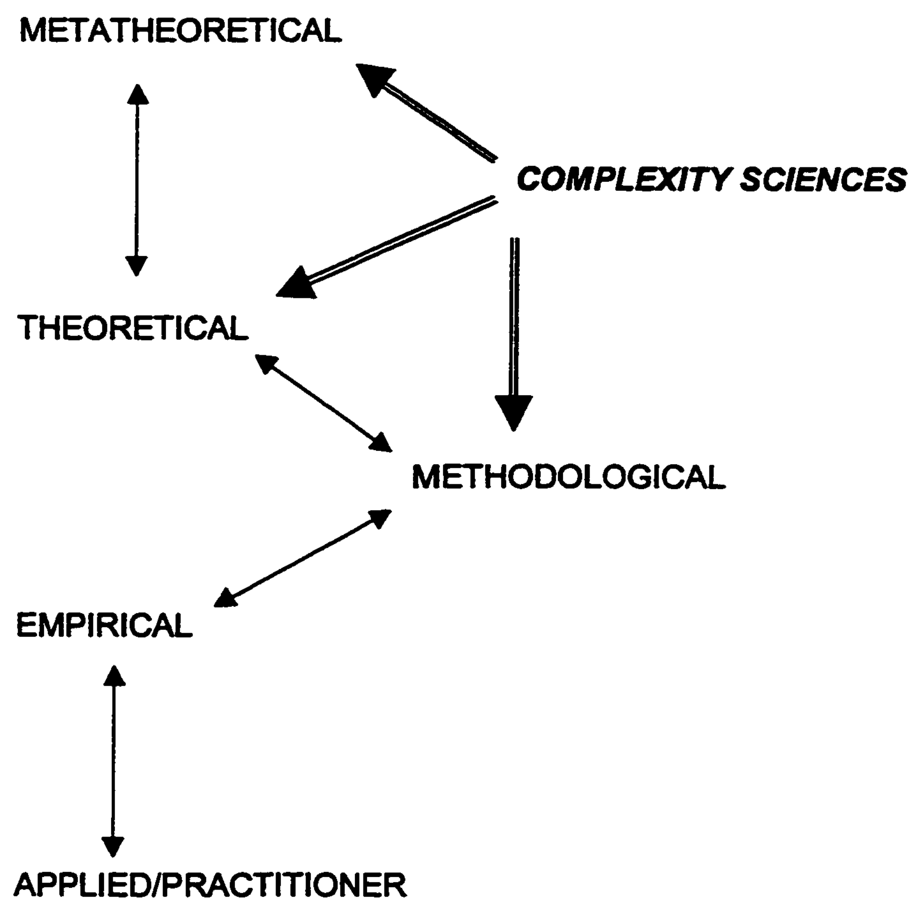
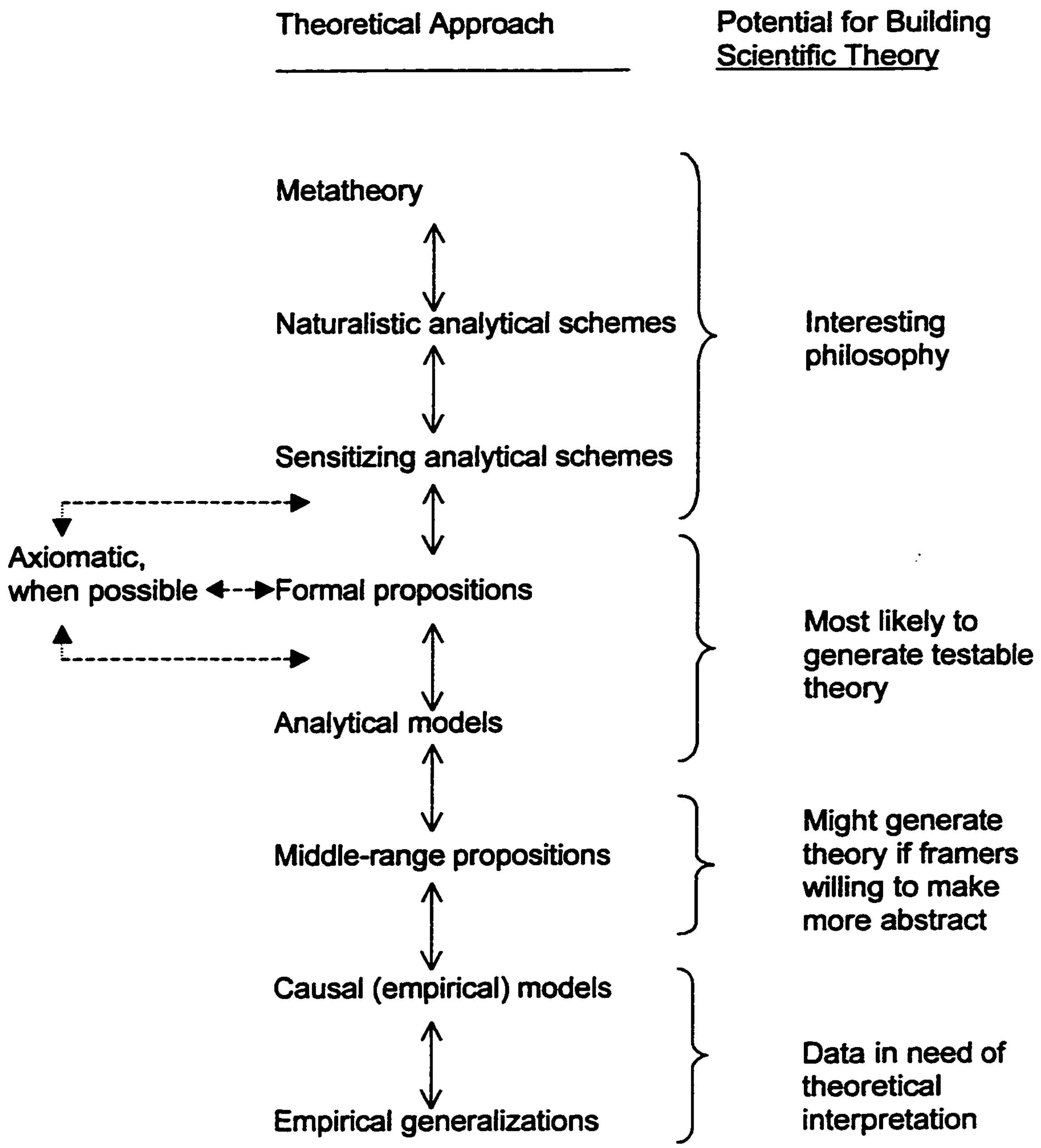


FIGURE 1.2: Levels of Analysis and the Complexity Sciences



Source: Turner, 1986.

FIGURE 1.3: Relations among Theoretical Approaches and Potential for Building Theory

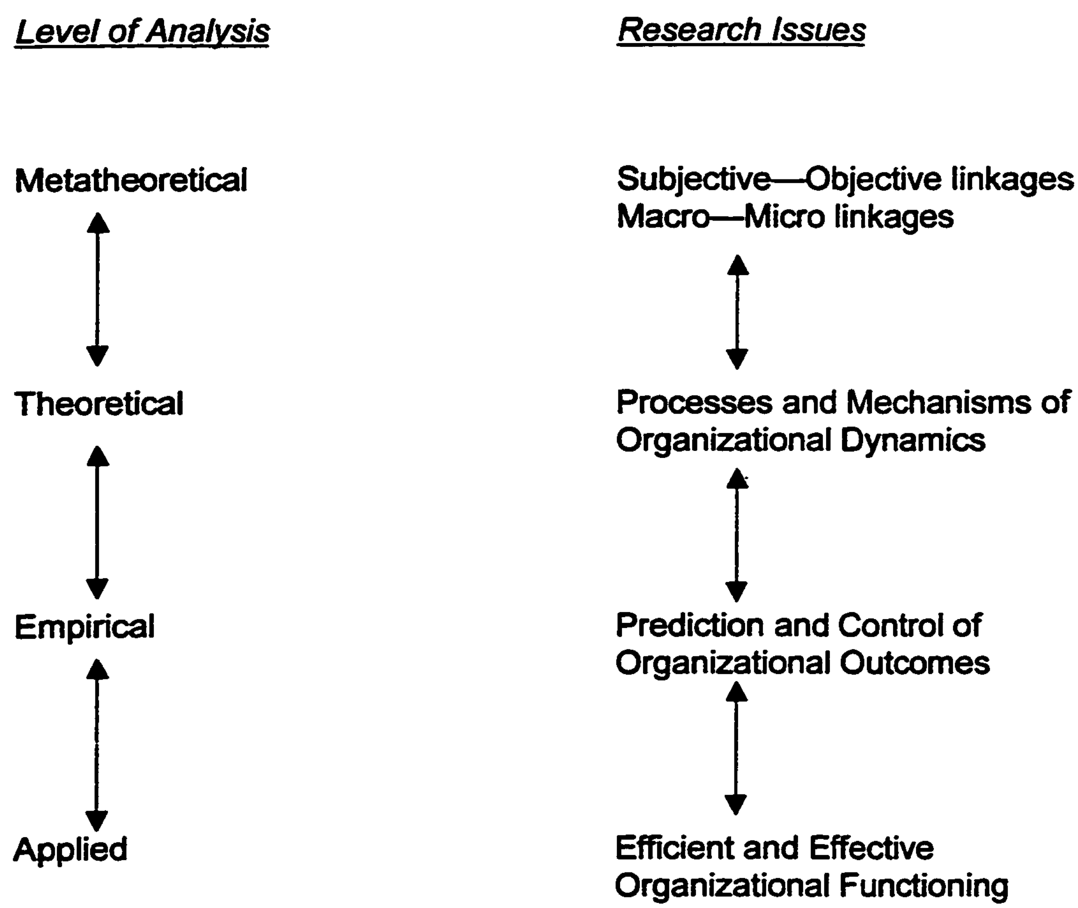


FIGURE 1.4: Levels of Analysis and Research Issues

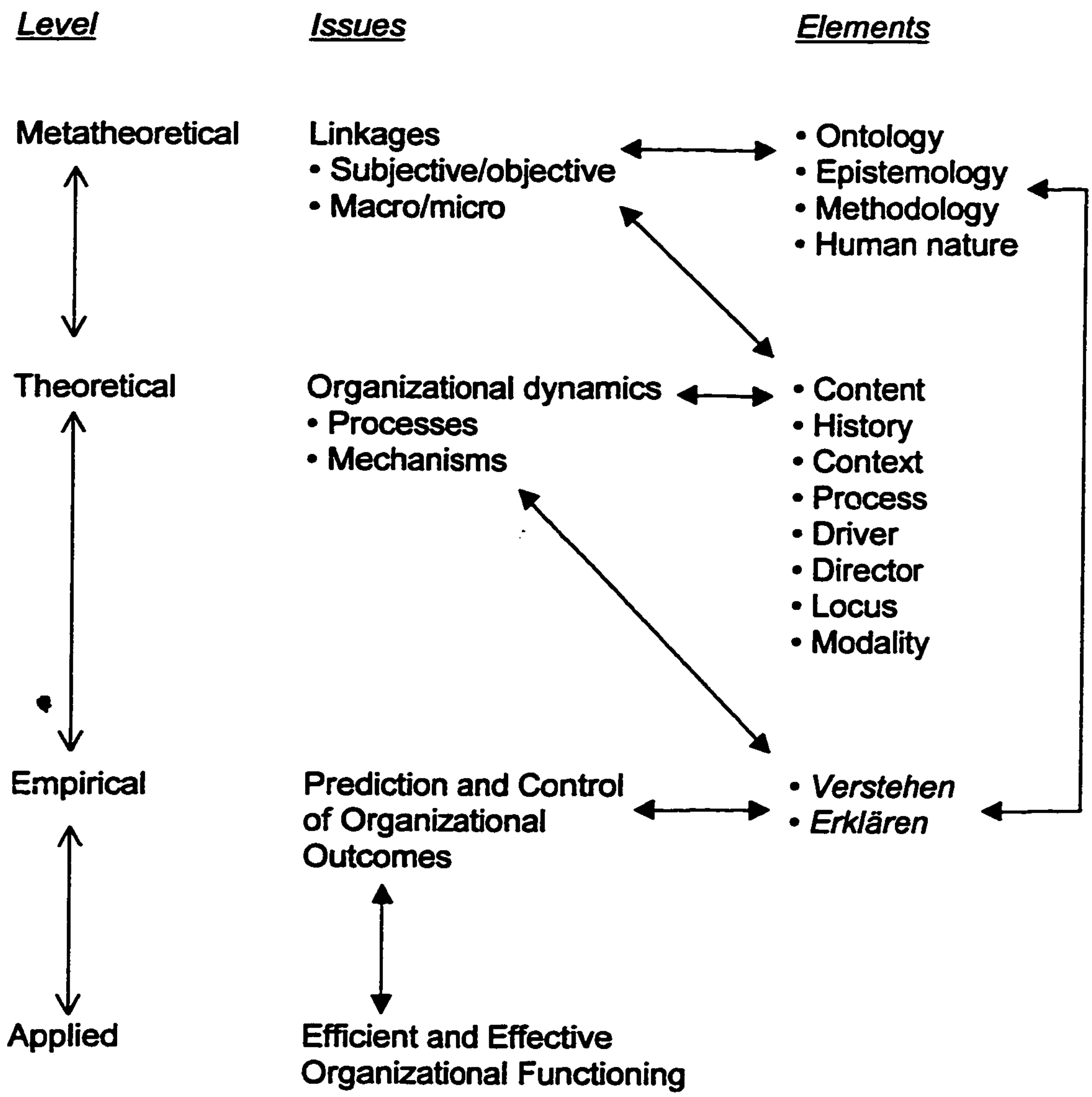
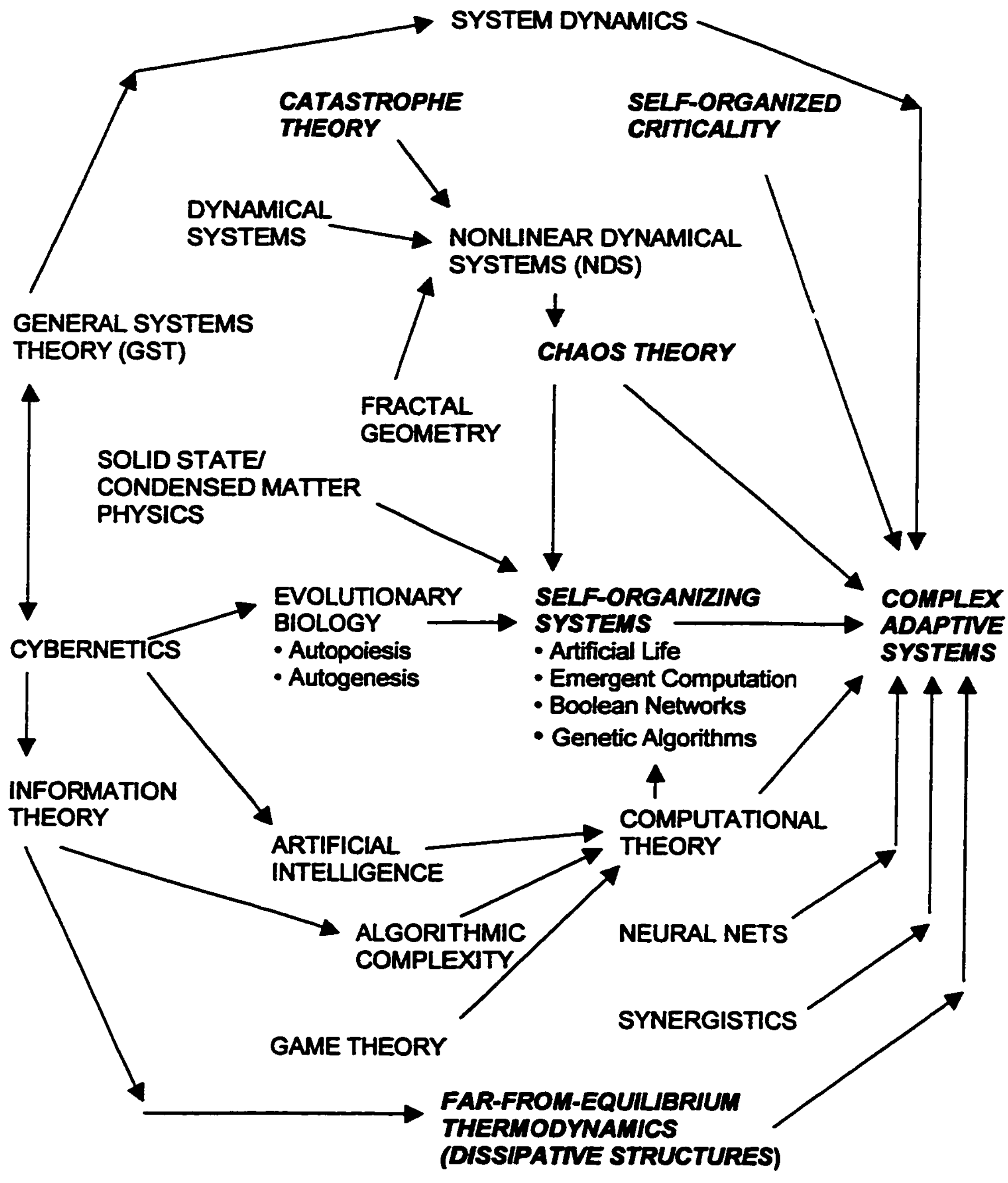
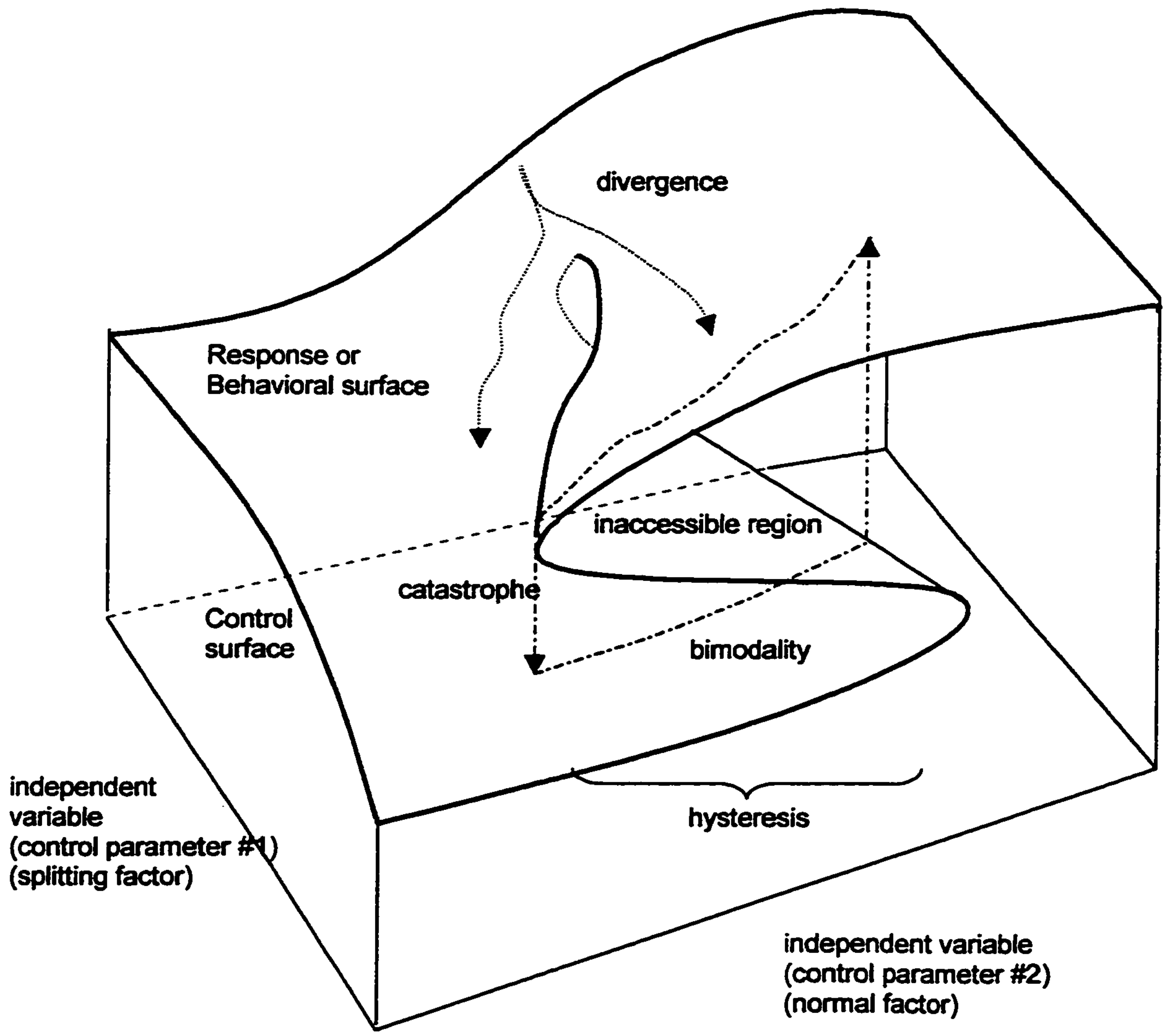


FIGURE 2.1: Elements in the Explanation of Organizational Dynamics



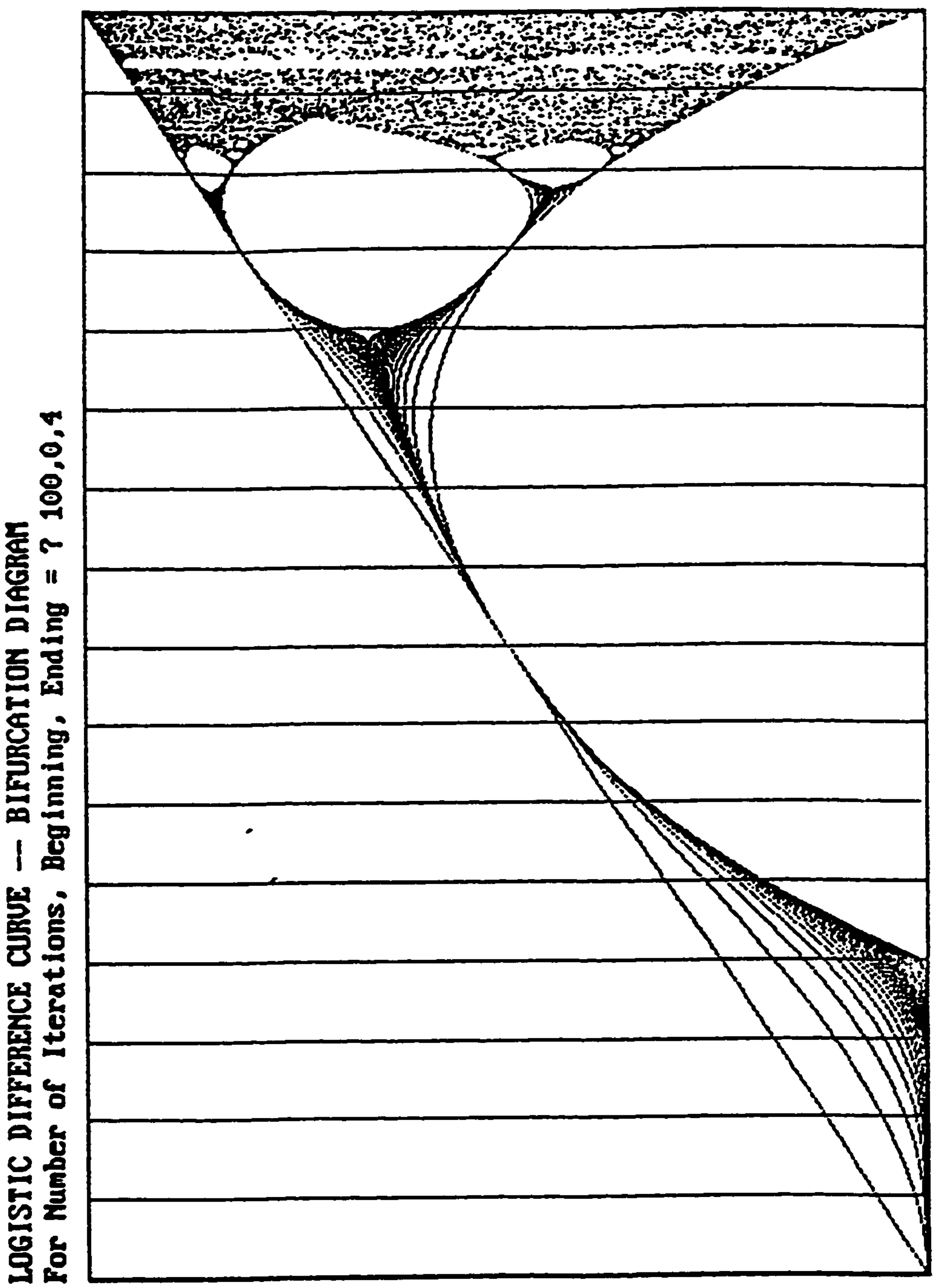
Adapted from the New England Complex Systems Institute (NECSI).

FIGURE 3.1: The Complexity Sciences



The response (behavioral) surface for the cusp model is that set of points where
$$\delta f(x)/\delta x = x^3 - a - bx$$

FIGURE 5.1: Illustration of the Cusp Model



Note: Values of the dependent variable (x_{t+1}) are plotted on the vertical axis at the end of each iteration. Values of k from 0 to 4 are plotted on the horizontal axis.

FIGURE 5.2a: Dynamic Behaviors in the Logistic Model
$x_{t+1} = x_t * k * (1 - x_t)$, 100 iterations for all values of k between 0 and 4

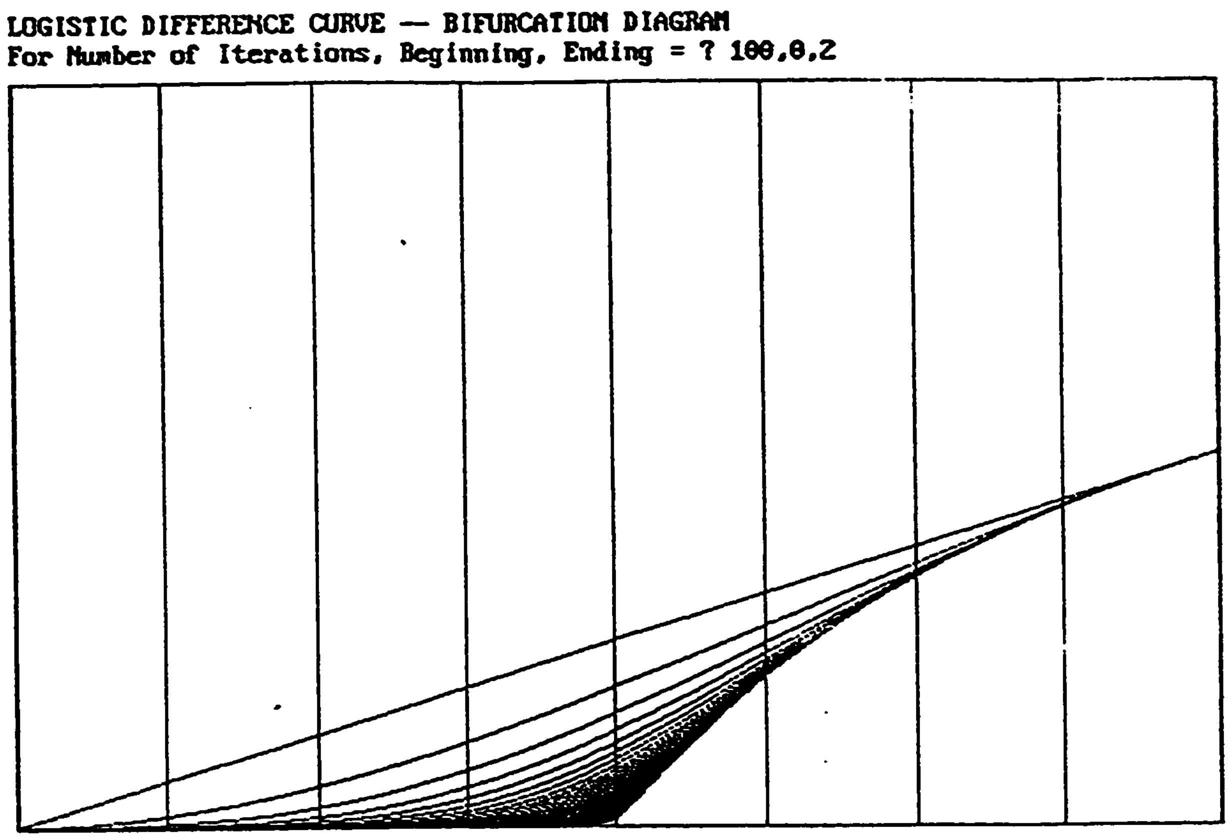


FIGURE 5.2b: Extinction and Stable Equilibrium
Logistic equation, 100 iterations for $0 \leq k \leq 2$

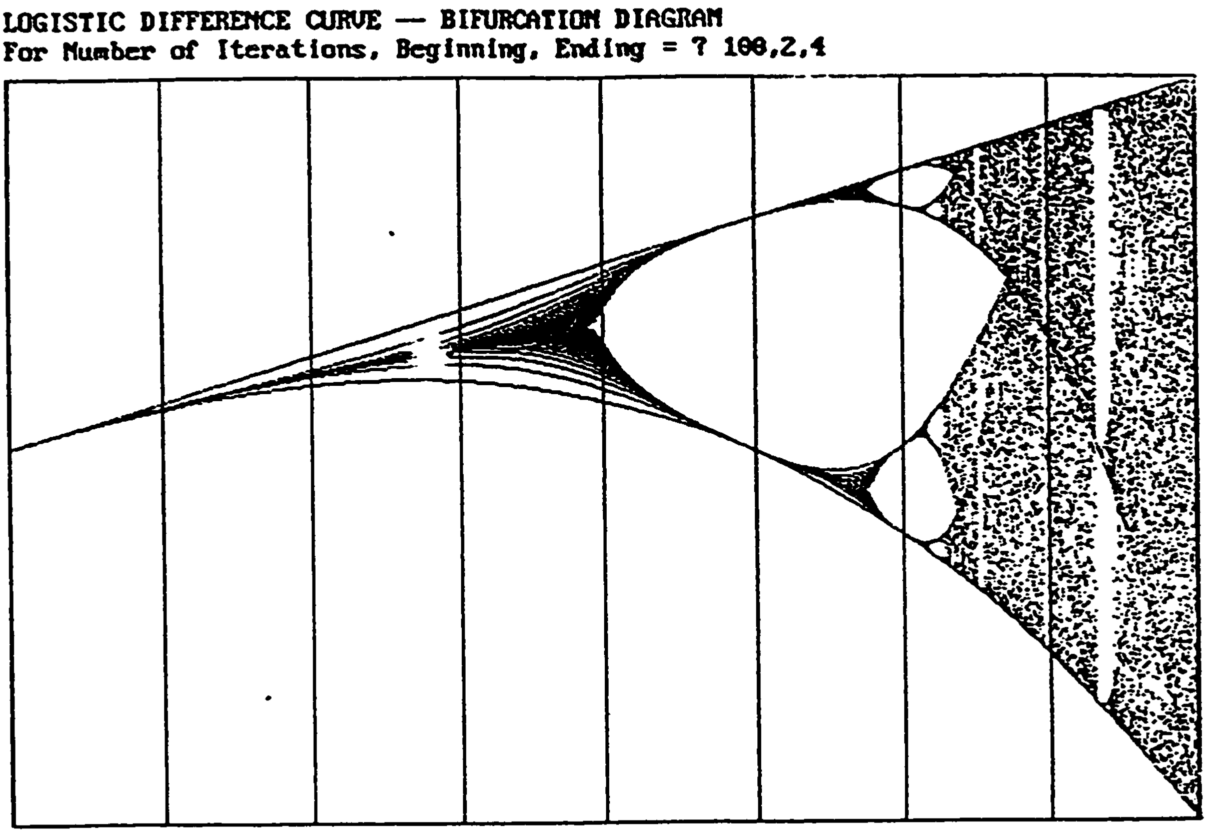


FIGURE 5.2c: Dynamic Equilibrium
Logistic equation, 100 iterations for $2 \leq k \leq 4$

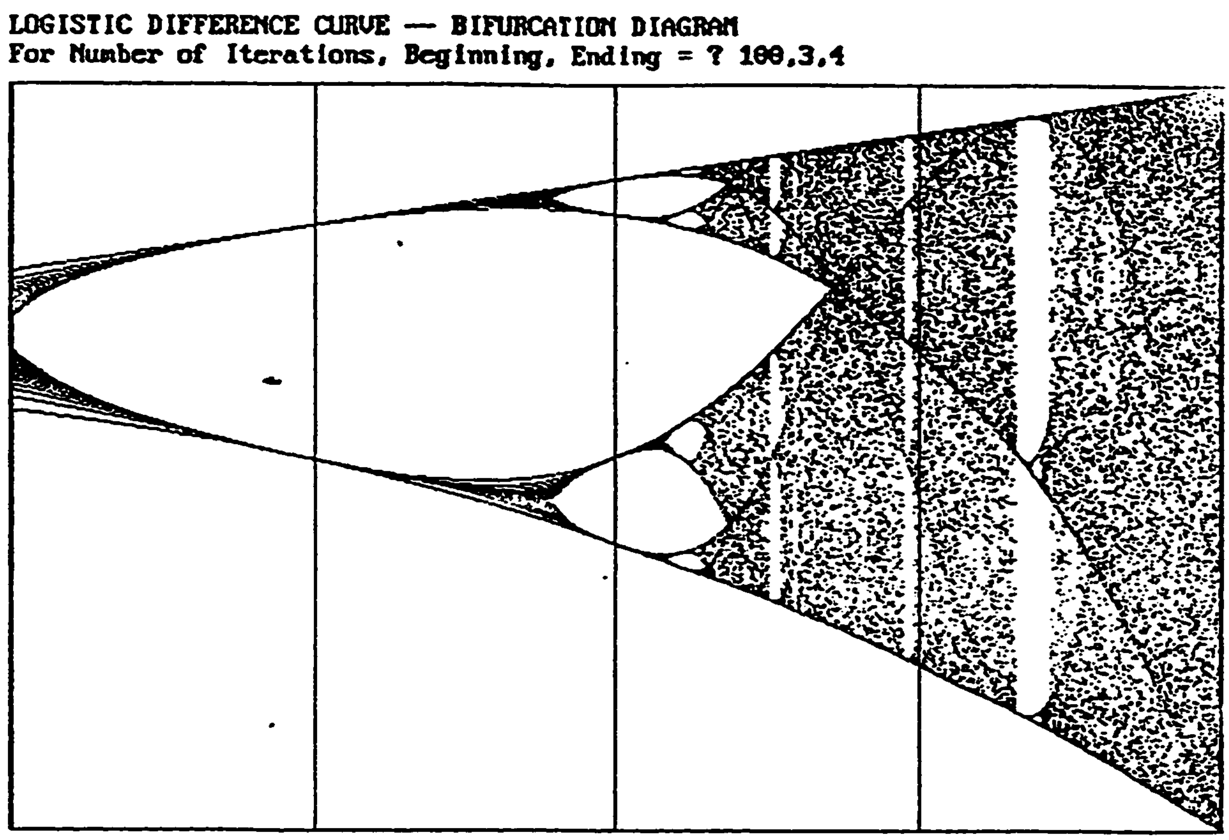


FIGURE 5.2d: Period-Doubling
Logistic equation, 100 iterations for $3 \leq k \leq 4$

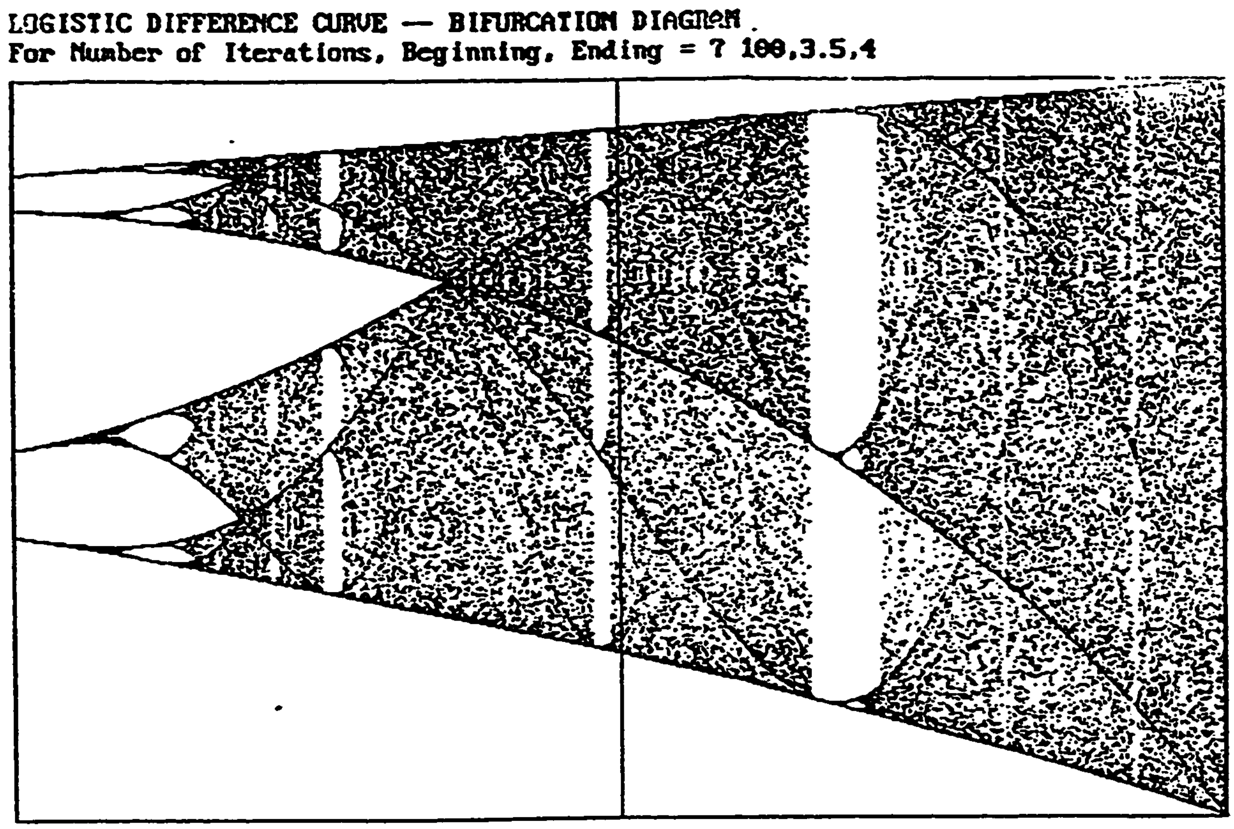


FIGURE 5.2e: Chaotic Behaviors
Logistic equation, 100 iterations for 3.5 ≤ k ≤ 4

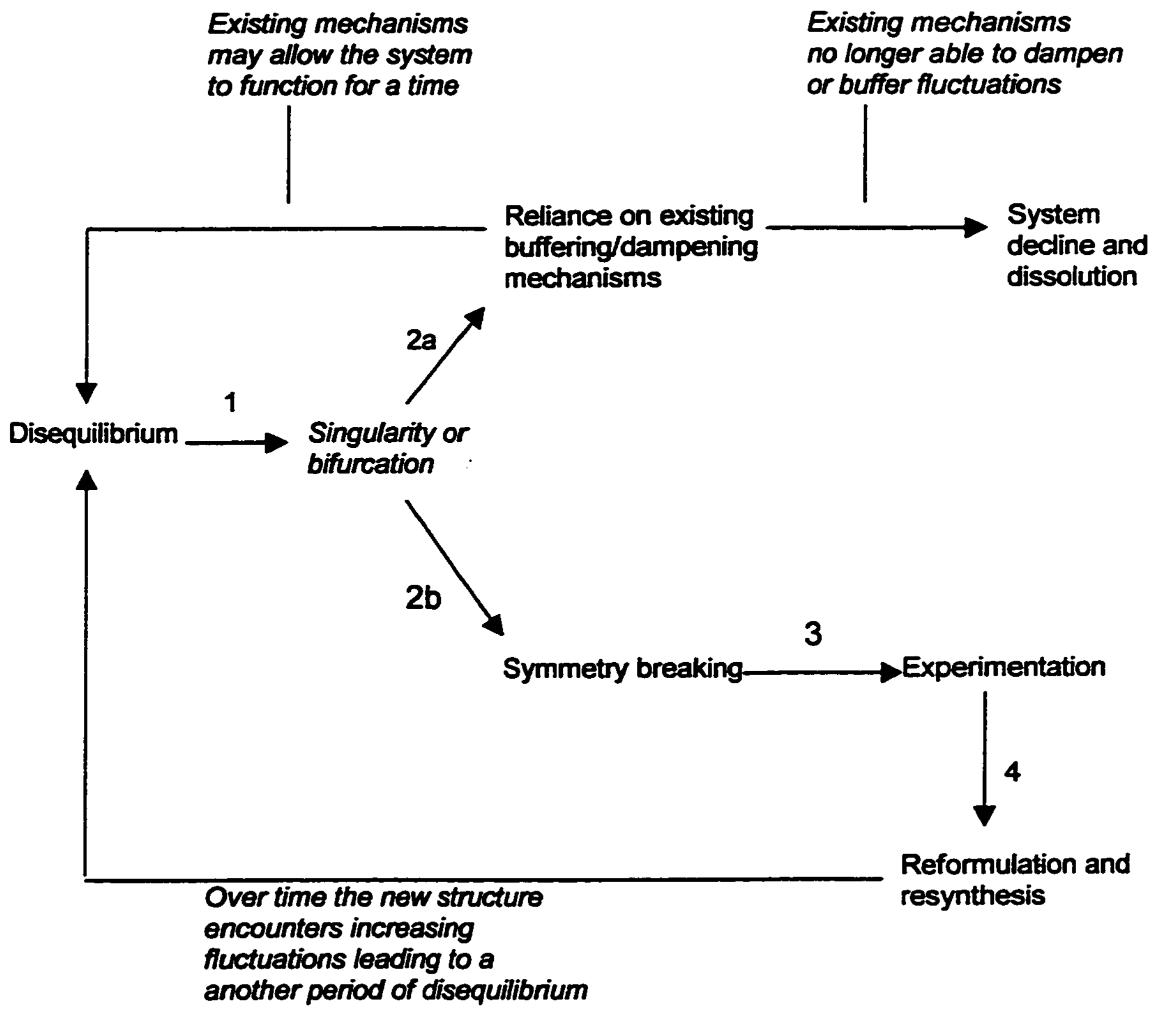


FIGURE 5.3: Elements of the Dissipative Process

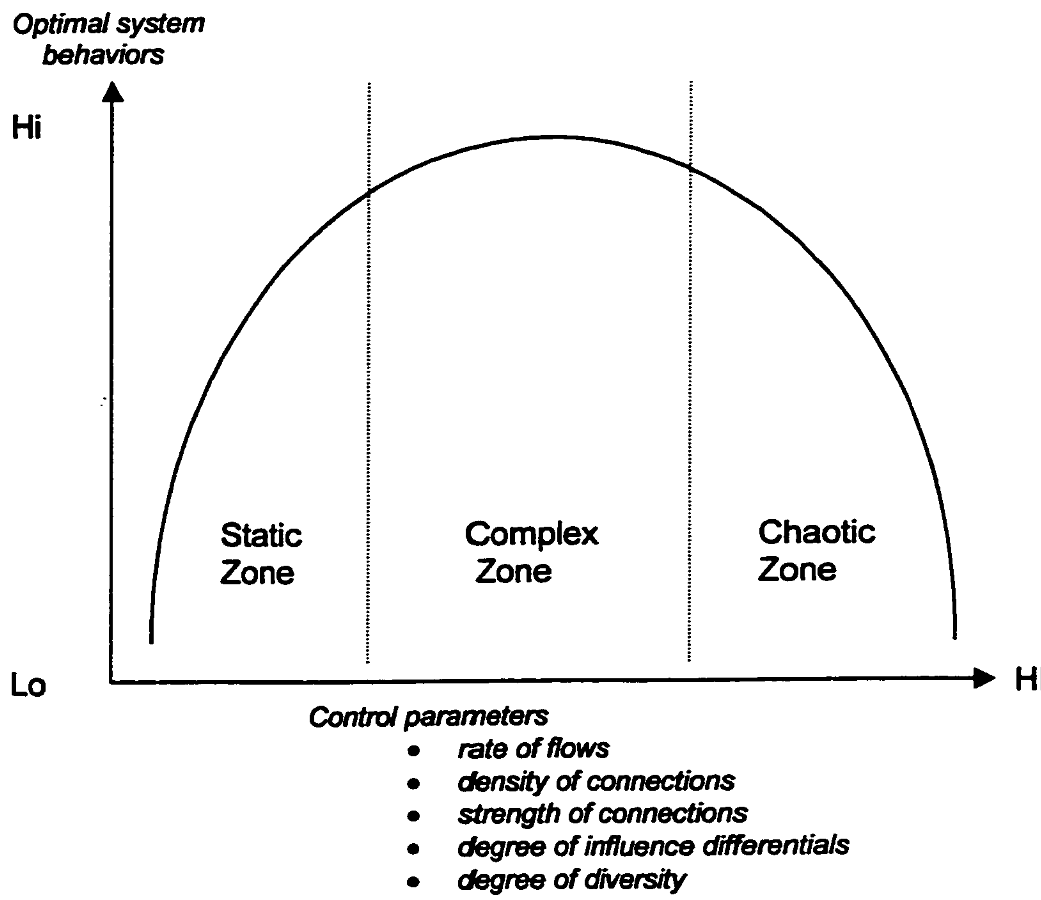
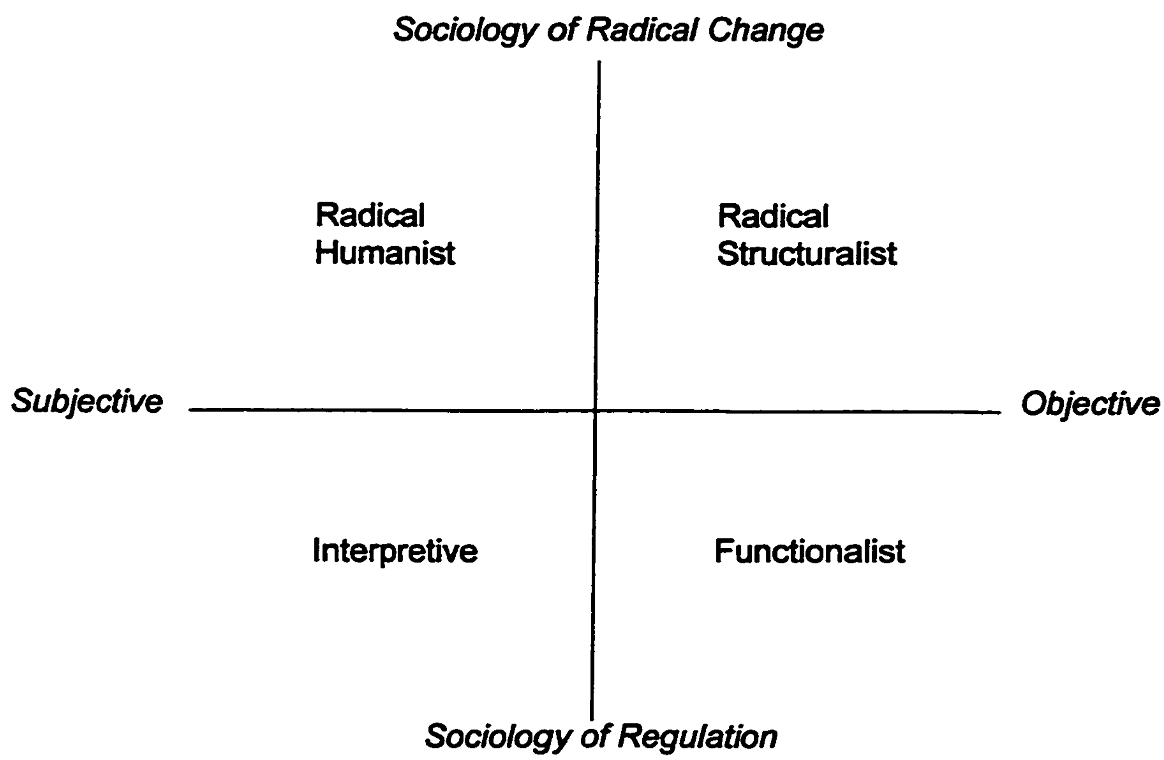


FIGURE 5.4: Control Parameters and System Behaviors



Source: Burrell and Morgan (1979: 22).

FIGURE 6.1: Four Paradigms for the Analysis of Social Theory

The subjectivist approach to <u>social science</u>		***The objectivist approach to <u>social science</u>***
Nominalism	***ontology***	Realism
Anti-positivism	***epistemology***	Positivism
Voluntarism	***human nature***	Determinism
Ideographic	***methodology***	Nomothetic

Source: Burrell and Morgan (1979: 3).

FIGURE 6.2: The Subjective–Objective Dimension

	Analytic theories	*Synthetic theories*
Dispersive theories	FORMISM (Root metaphor: similarity)	CONTEXTUALISM (Root metaphor: historic event)
Integrative theories	MECHANISM (Root metaphor: the machine)	ORGANICISM (Root metaphor: integrated whole)

Source: Tsoukas (1994: 763).

FIGURE 6.3: World Hypotheses (Pepper, 1942)

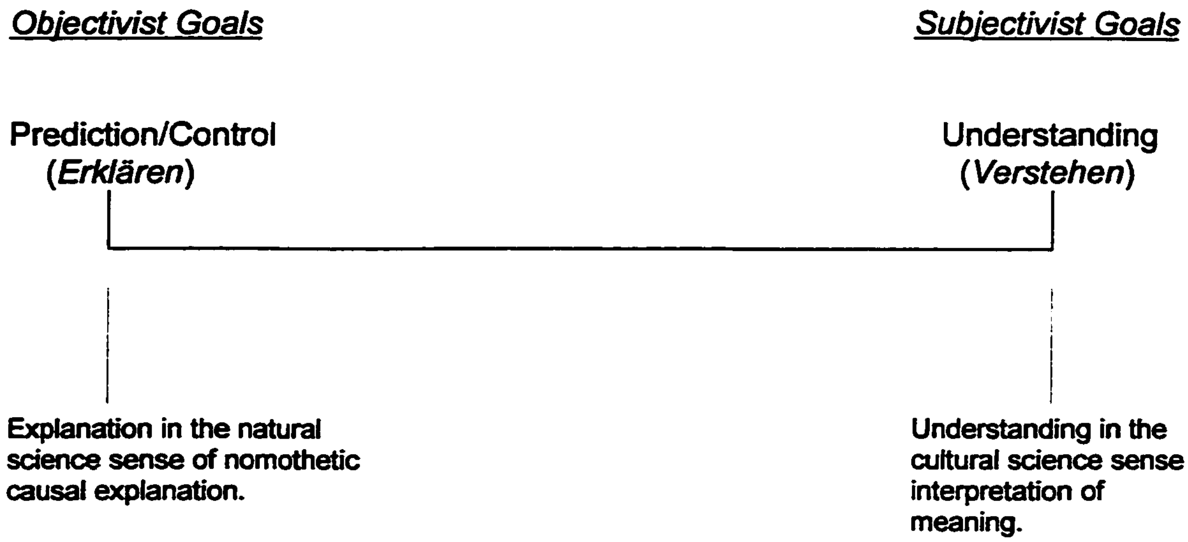
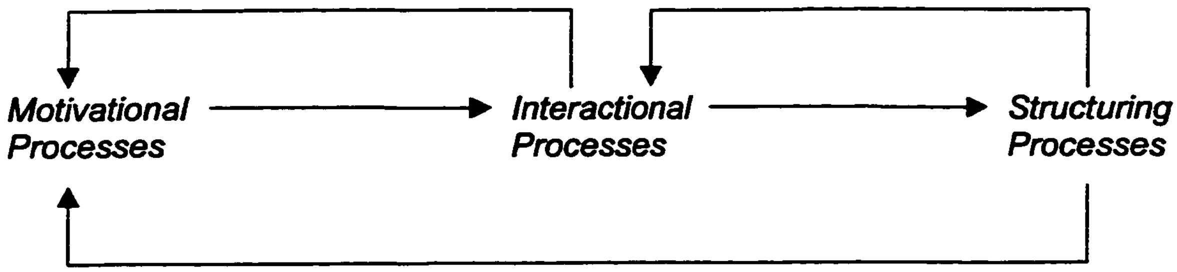


FIGURE 6.4: Reconceptualization of the Subjective/Objective Dimension



Source: Turner (1988:15).

FIGURE 7.1: Elements of Social Interaction

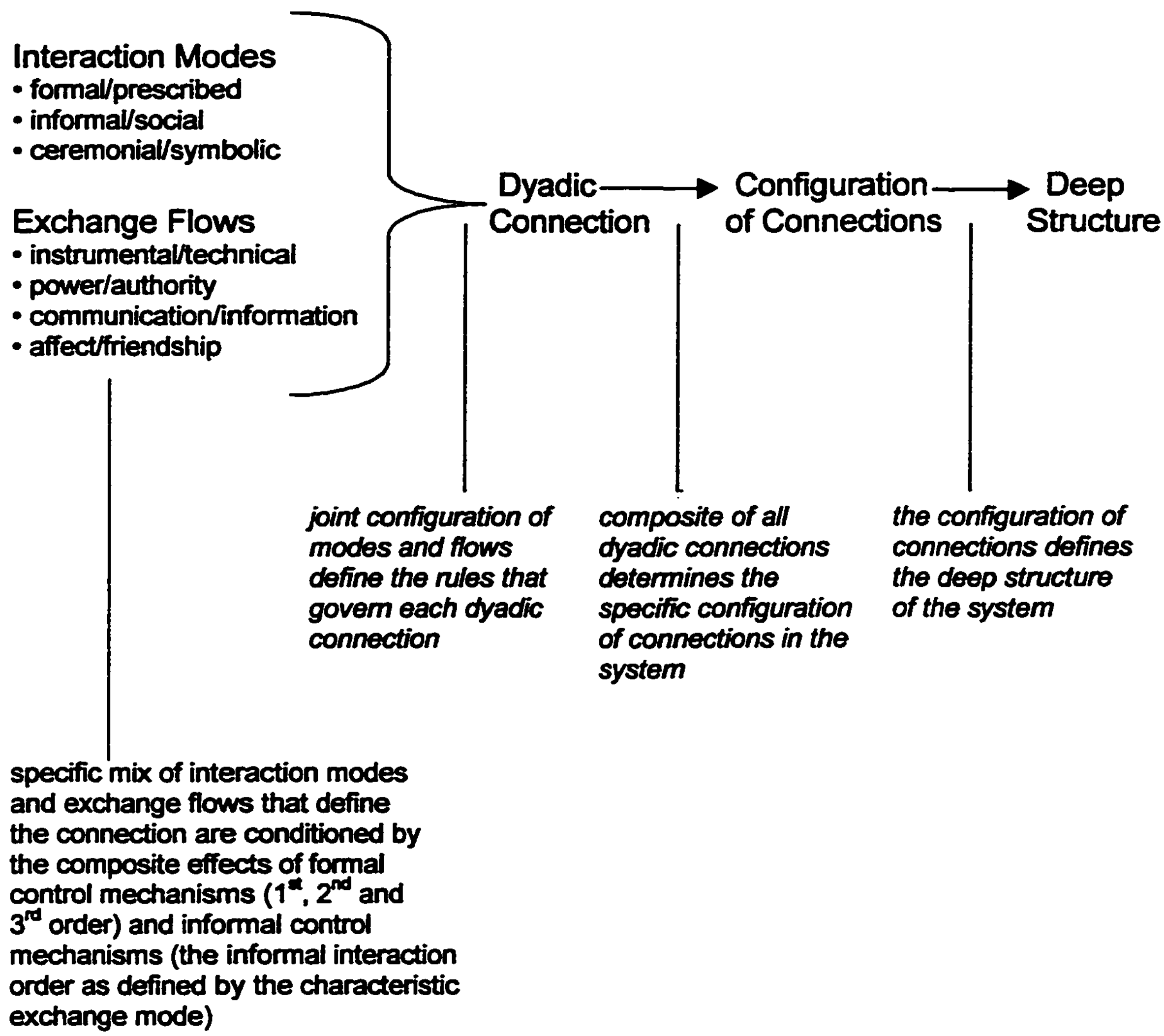


FIGURE 7.2: Multidimensional Connections and Deep Structure

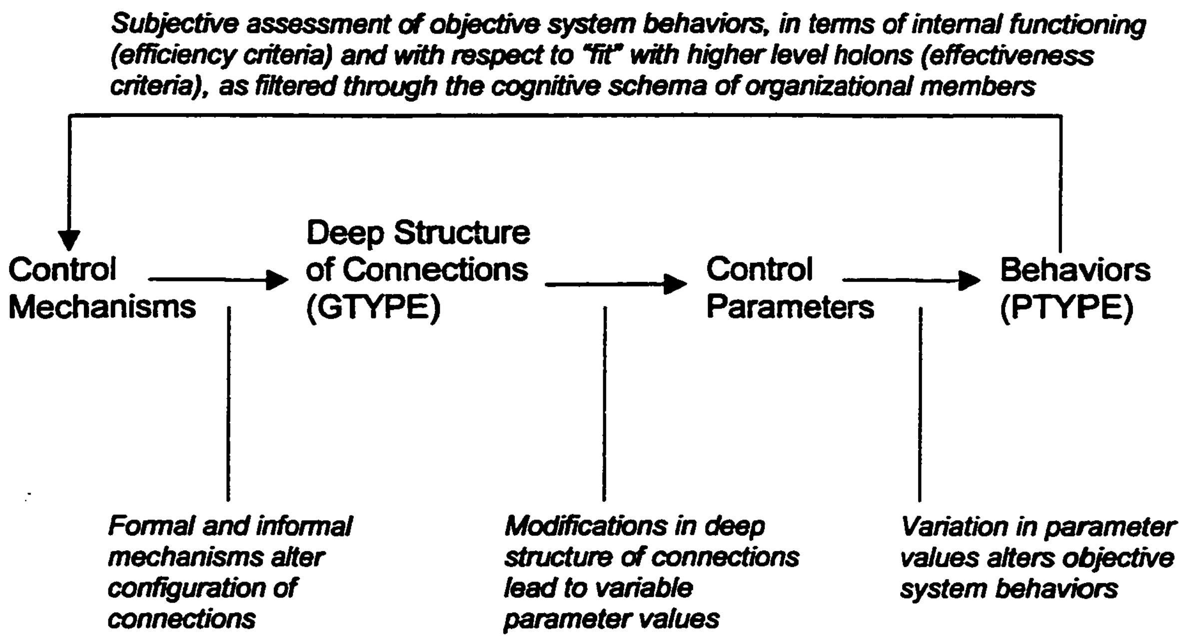


FIGURE 7.3a: Relationship between Deep Structure and Behaviors

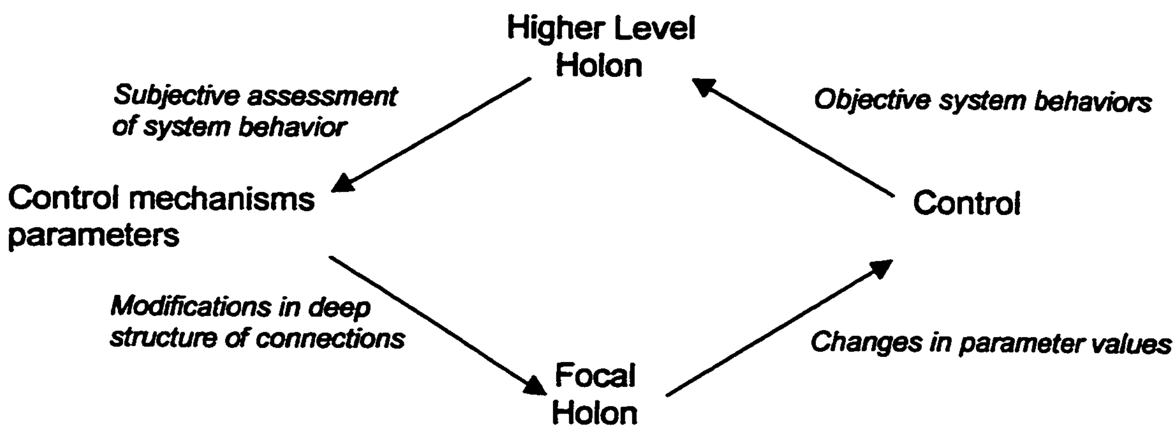


FIGURE 7.3b: Mechanisms, Parameters and Levels

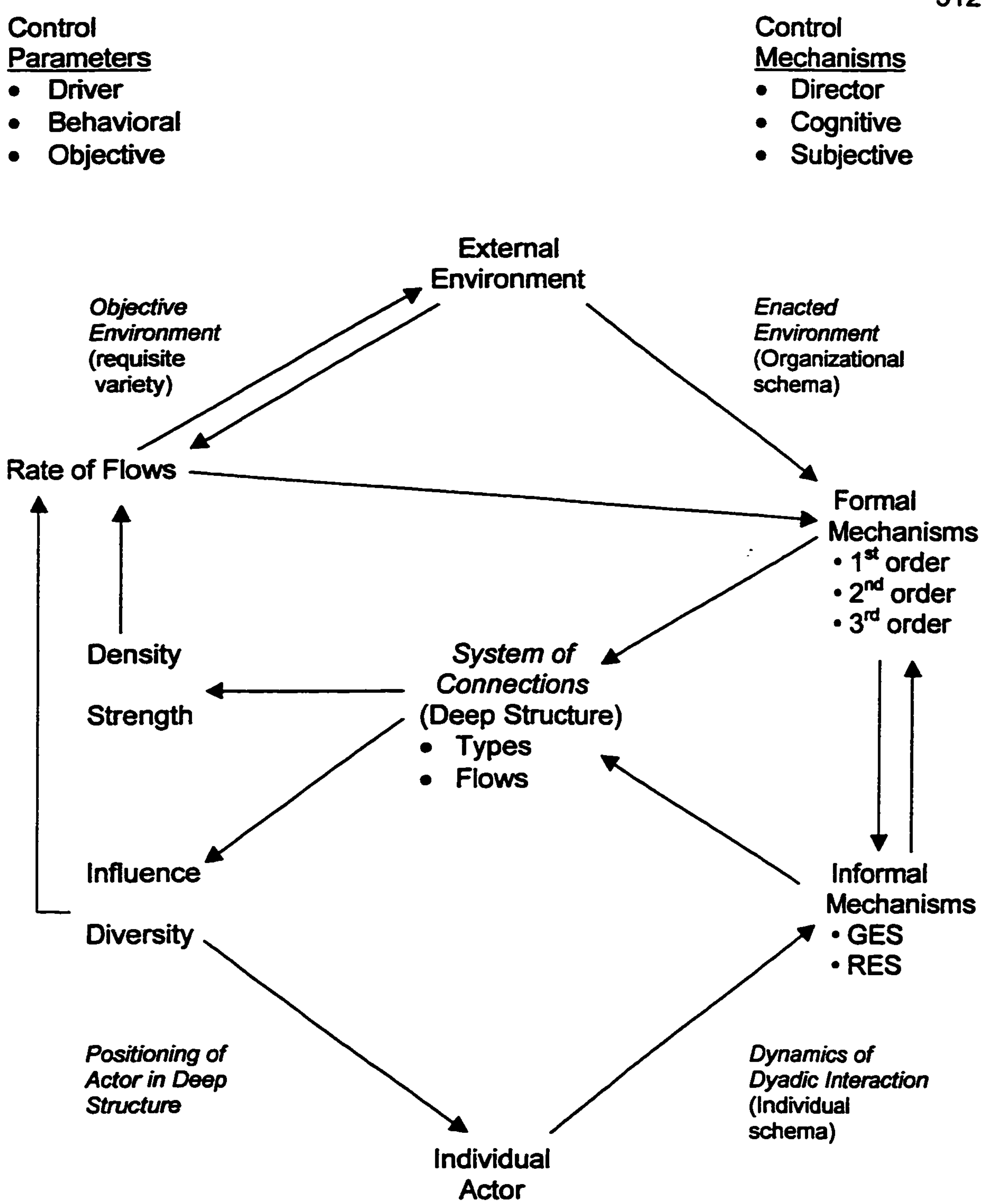


FIGURE 7.4: Spatial Dynamics and Organizational Systems

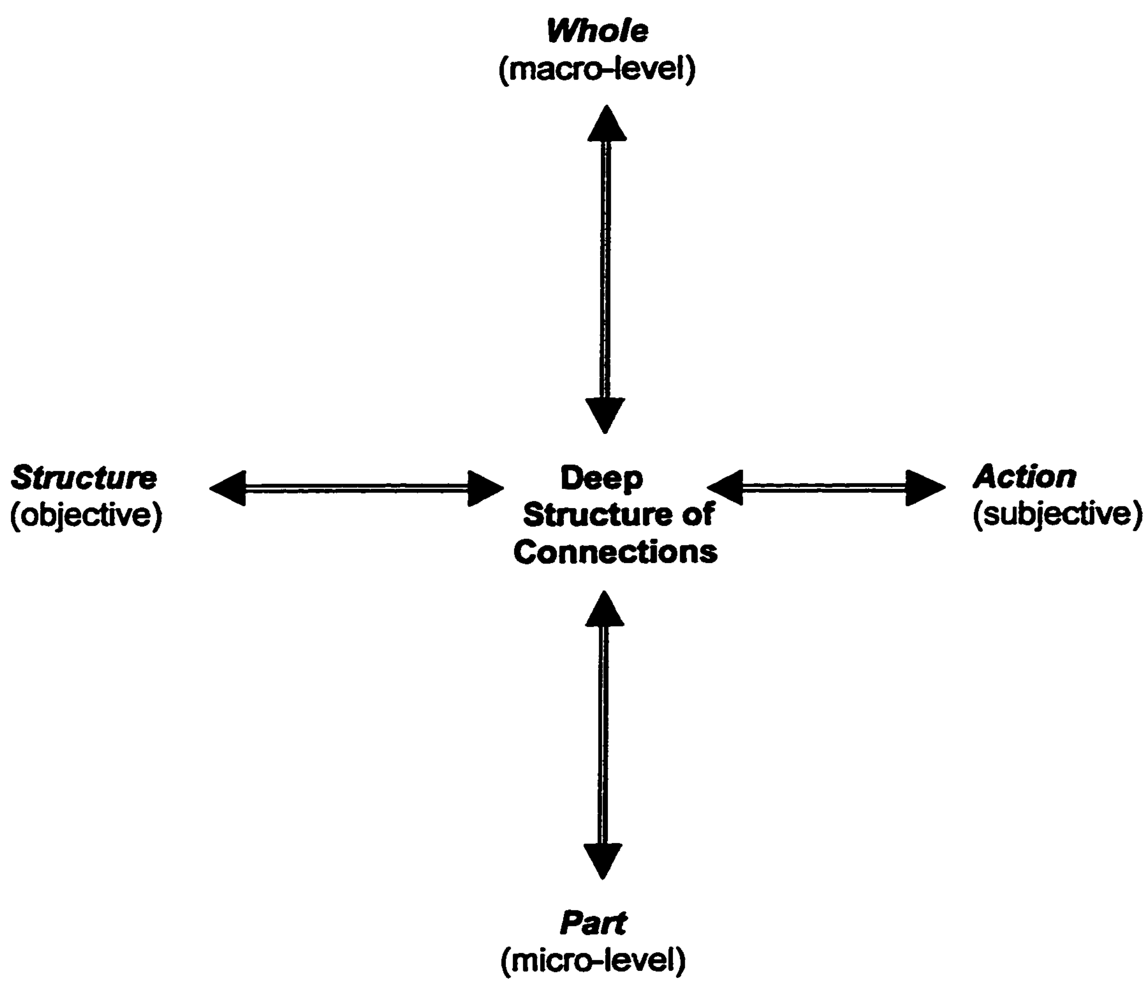


FIGURE 7.5: Part/Whole and Structure/Action Dialectics

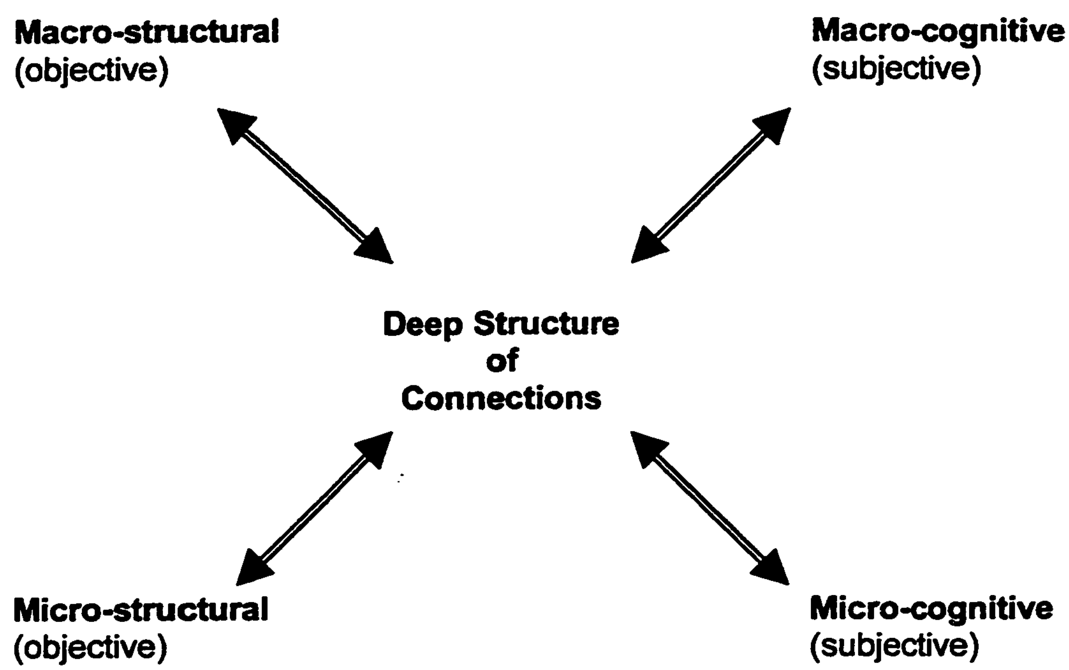


FIGURE 7.6: Linking Macro/Micro and Subjective/Objective

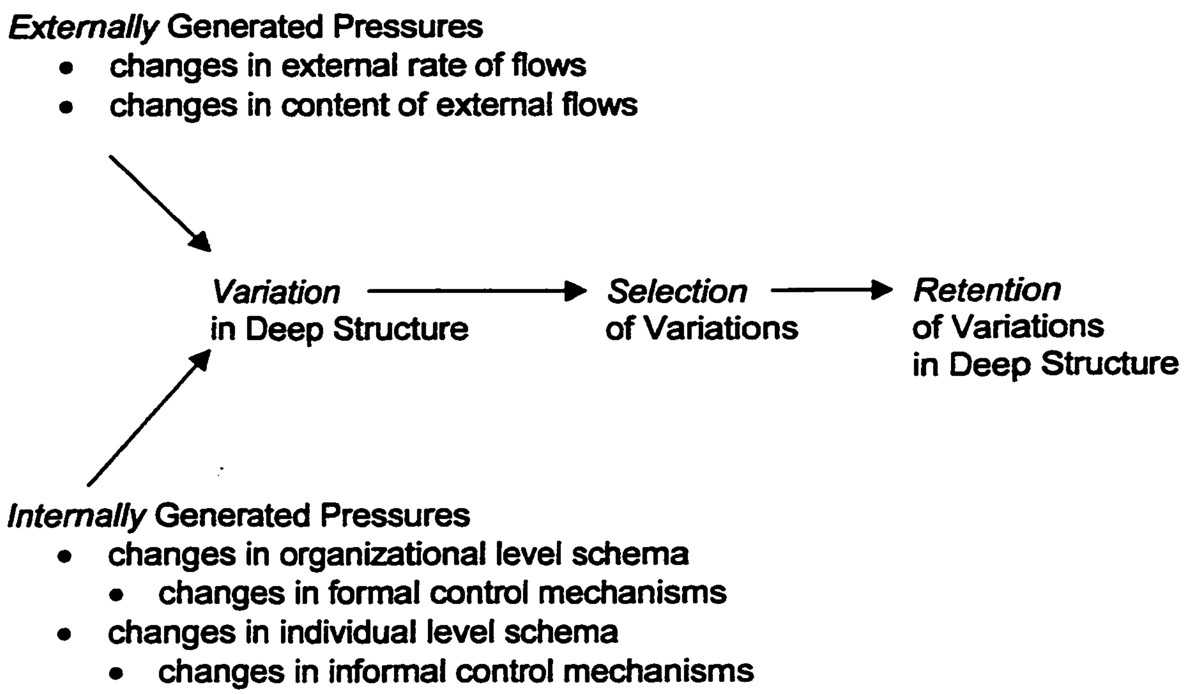
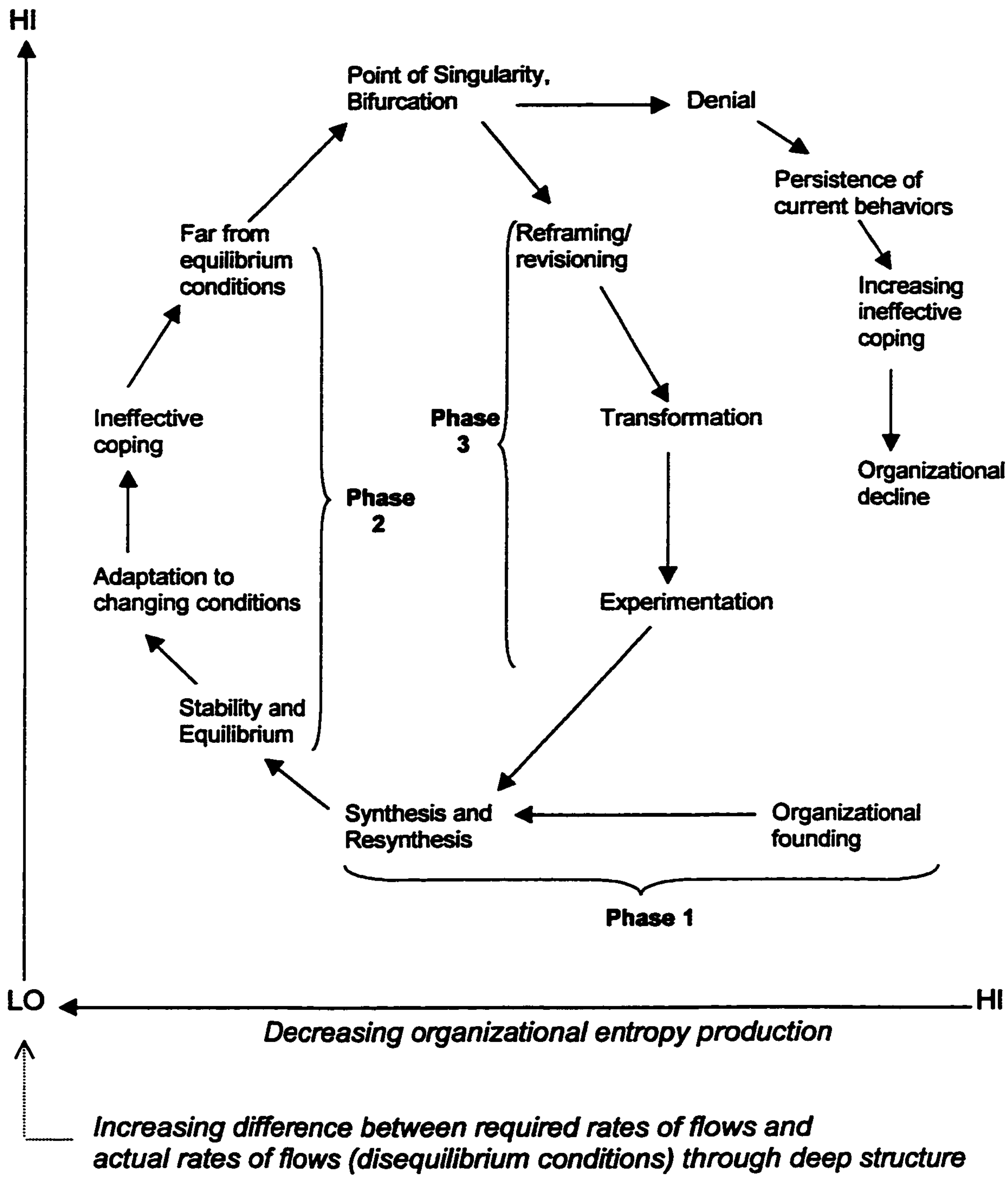


FIGURE 7.7: Temporal Dynamics of Organizational Systems
(Developmental and Transformational Change Processes)



Adapted from Leifer (1989: 907).

FIGURE 8.1 Developmental and Transformational Dynamics

Mode	**Strategic Planning**	**Strategic Management**	**Strategic Learning**
Characteristic structure	mechanistic	organic	complex adaptive
Characteristic attributes	centralized, authoritarian, high formalization		decentralized, participatory, low formalization
Characteristic environment	relatively stable, predictable		complex, dynamic, uncertain
Characteristic learning mode	adaptive, single-loop, exploitation learning		generative, double-loop, exploration learning
Characteristic control mechanism	primary reliance on 1^{st} order control mechanisms		primary reliance on 2^{nd} and 3^{rd} order control mechanisms

FIGURE 8.2: Characteristics of Direction Setting Modes

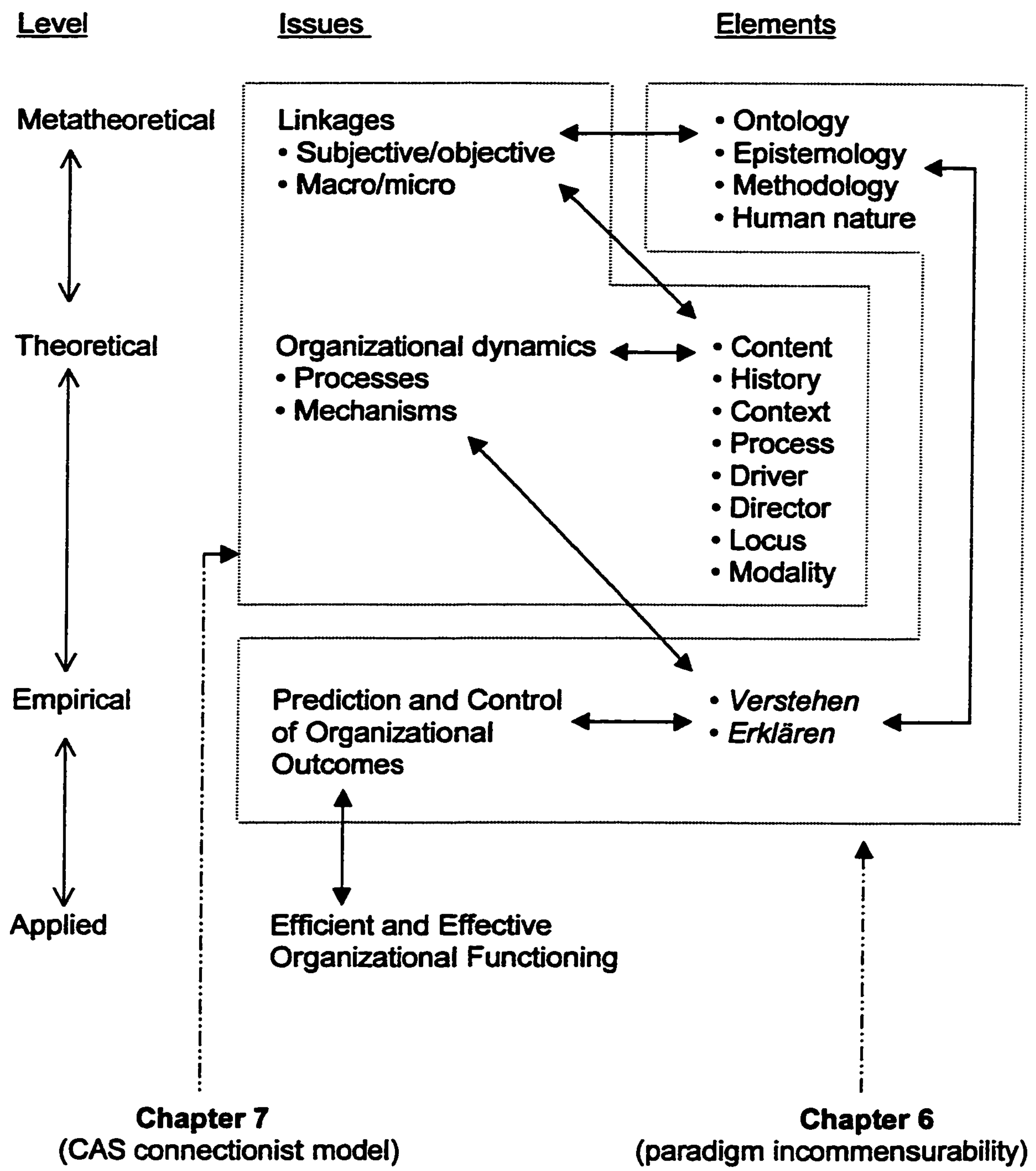


FIGURE 8.3: Issues in the Explanation of Organizational Dynamics
Implications from the Complexity Sciences

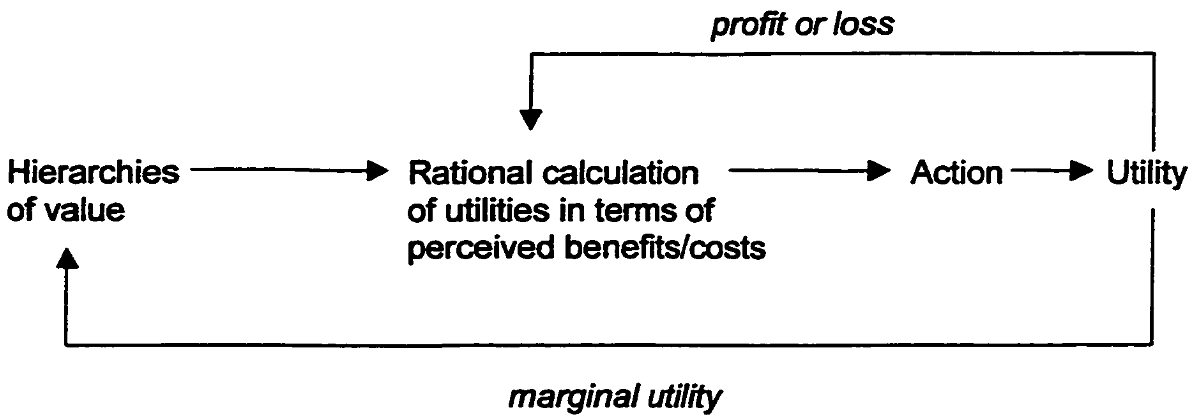


FIGURE A.1: Utilitarian Model of Motivation

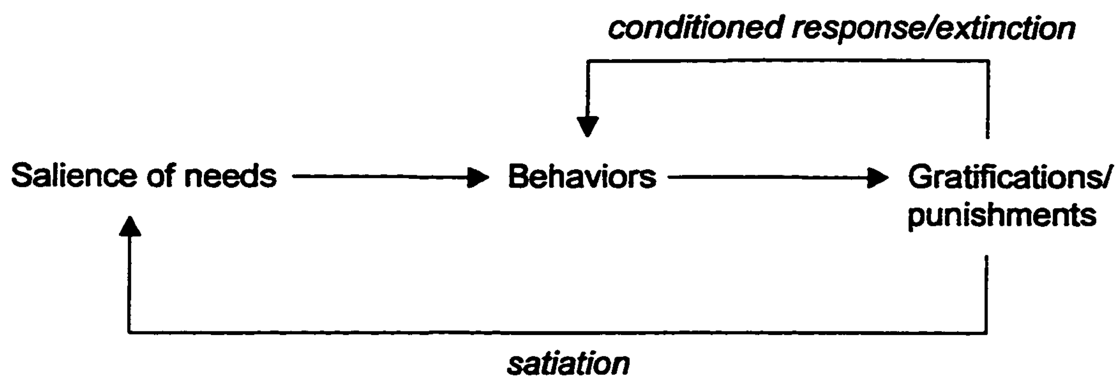


FIGURE A.2: Behaviorist Model of Motivation

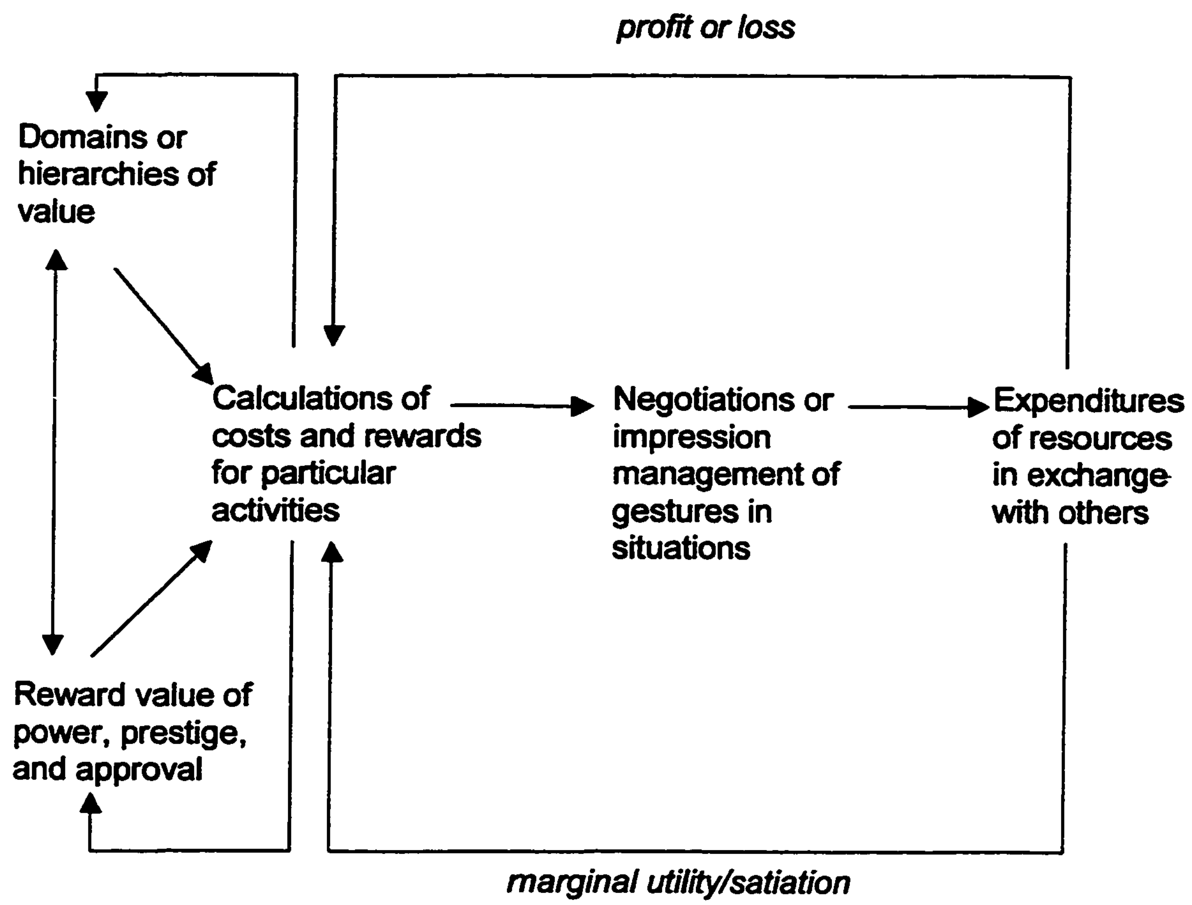


FIGURE A.3: Exchange-Theoretic Model of Motivation

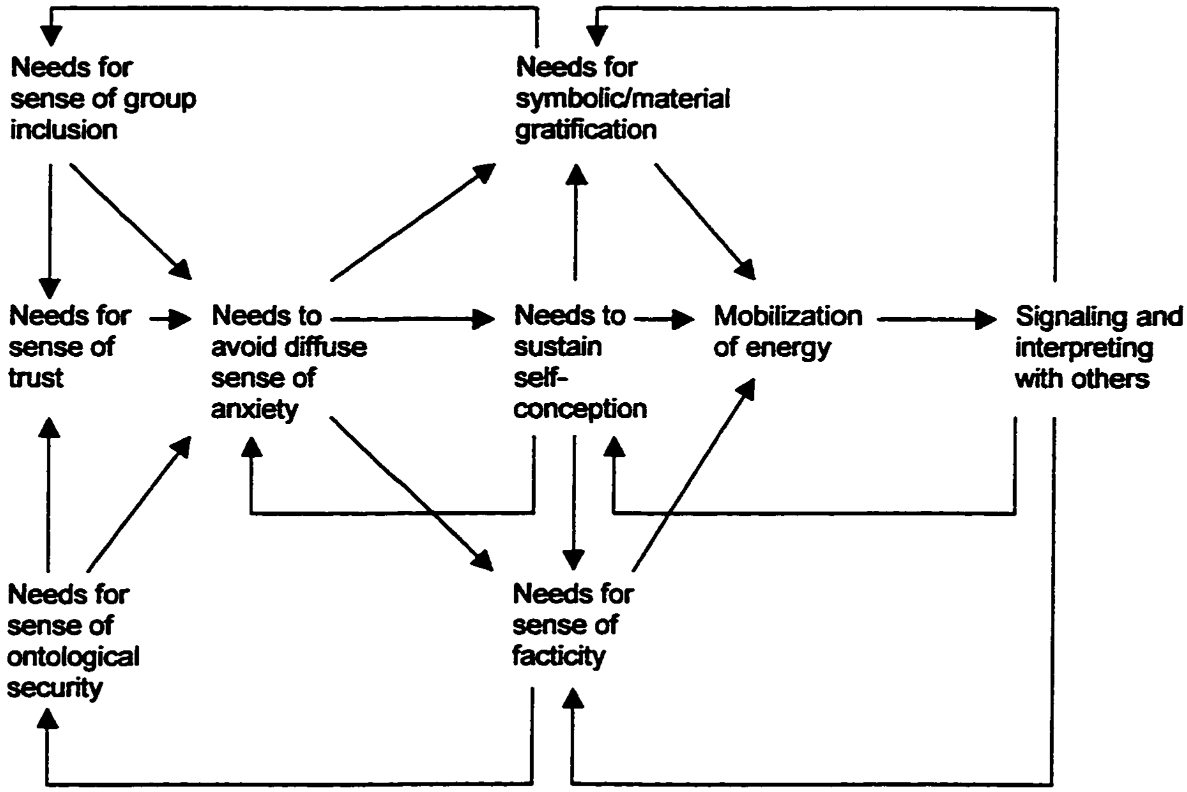


FIGURE A.4: Dynamic Model of Motivational Processes

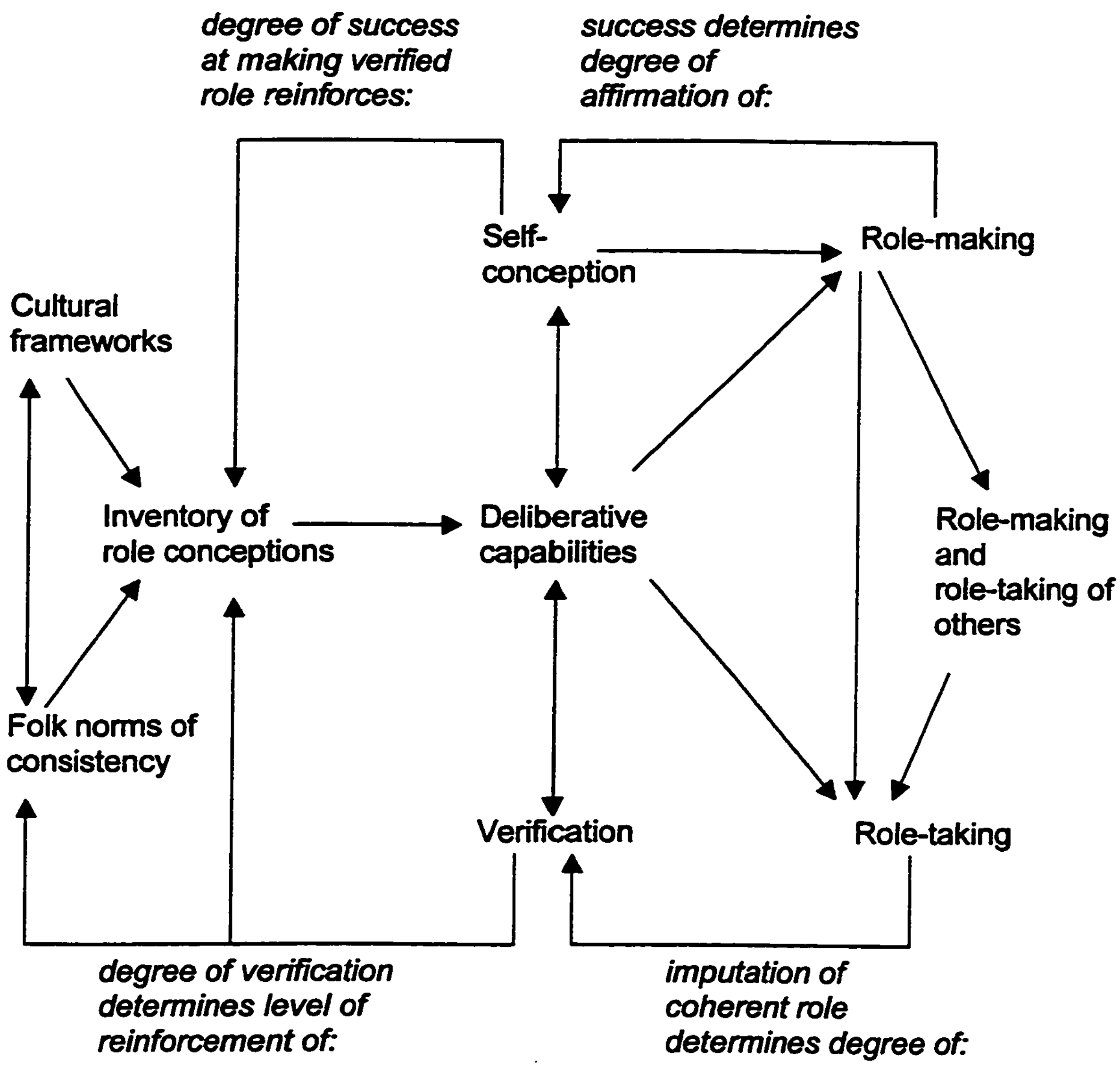


FIGURE A.5: Role-making, Role-taking and Interaction

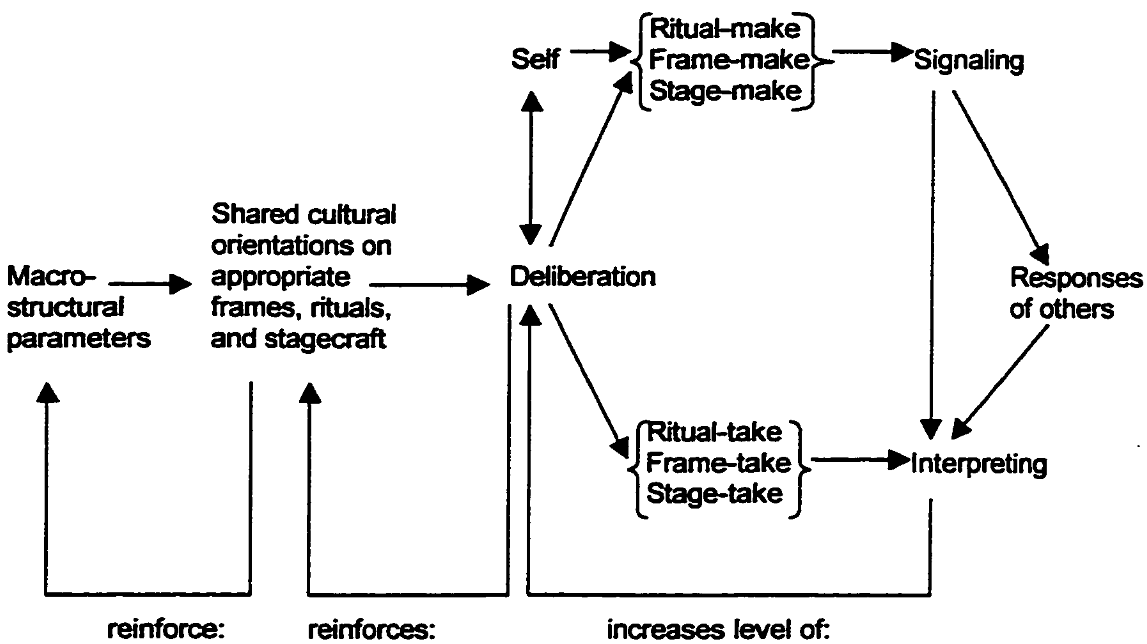


FIGURE A.6: Dramaturgical Analysis and Interaction

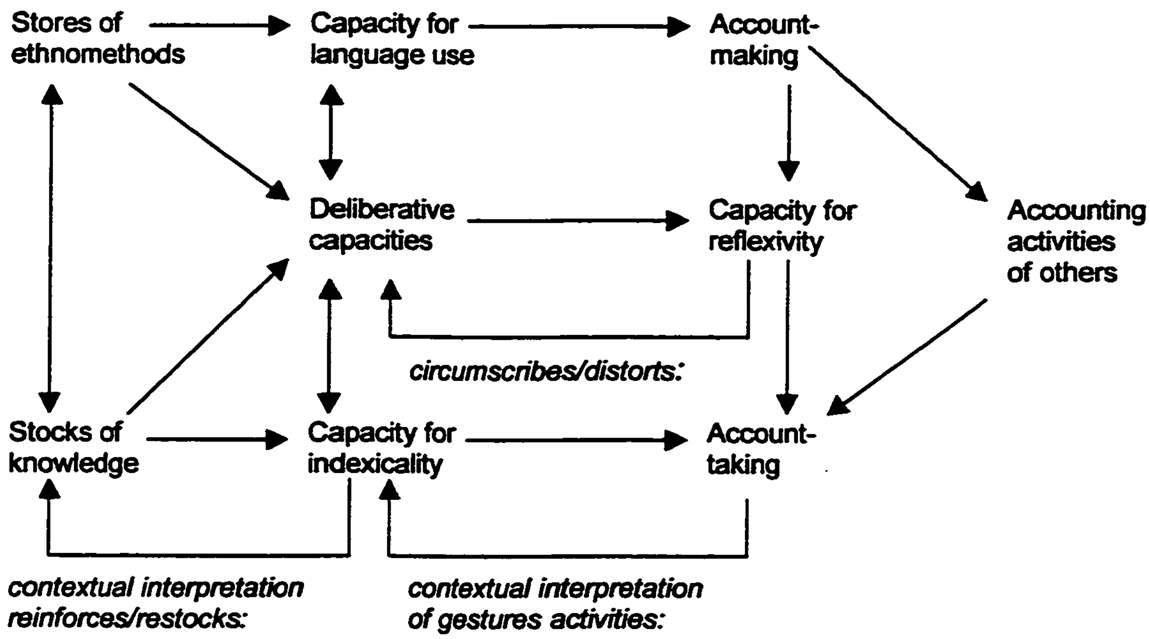


FIGURE A.7: Ethnomethods and Interaction

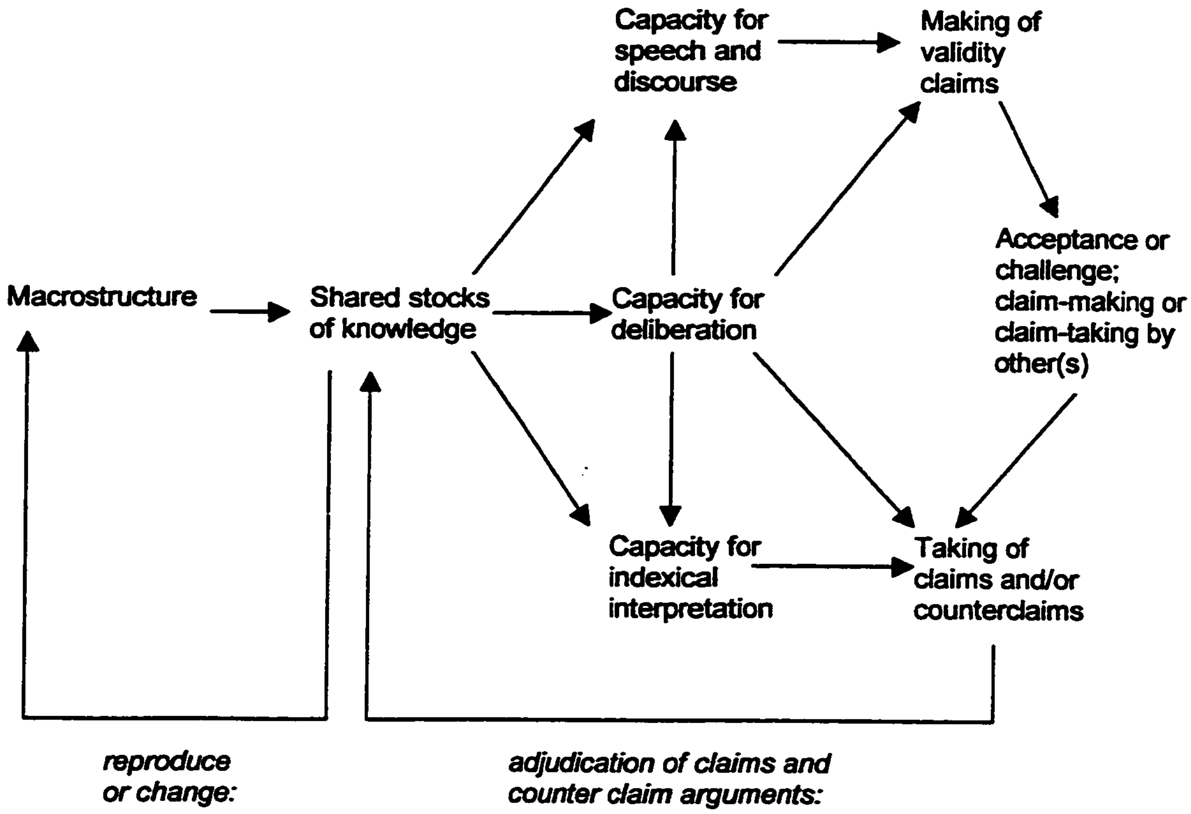


FIGURE A.8: Claim-making, Claim-taking and Interaction

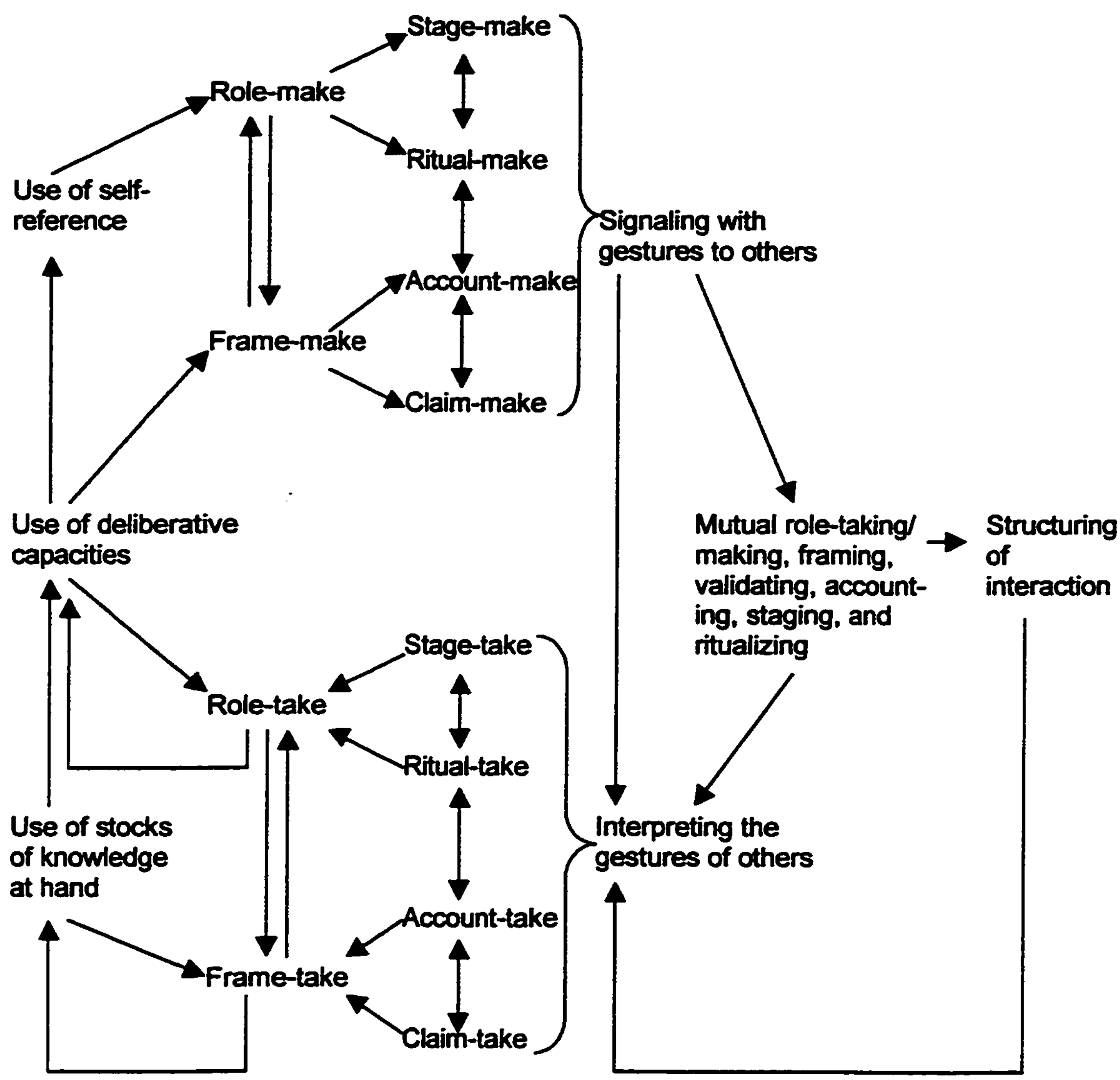


FIGURE A.9: Dynamic Model of Interaction Processes

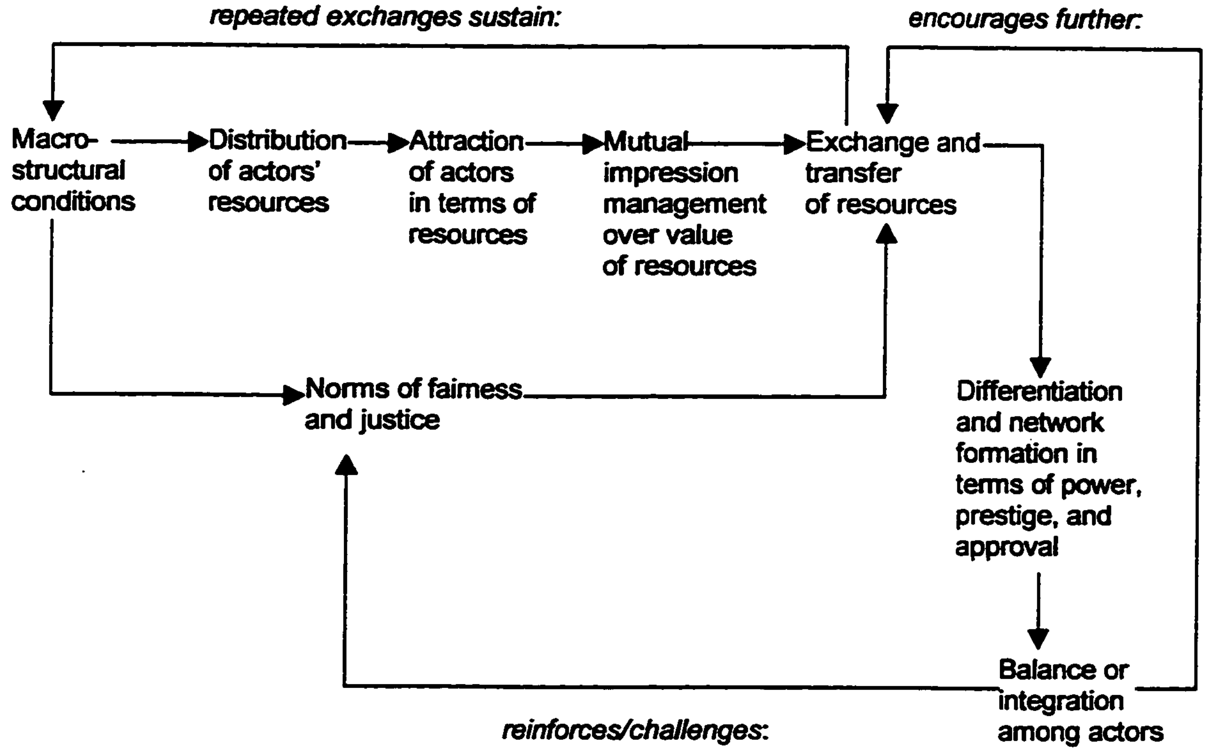


FIGURE A.10: Exchange-Theoretic Model of Structuring

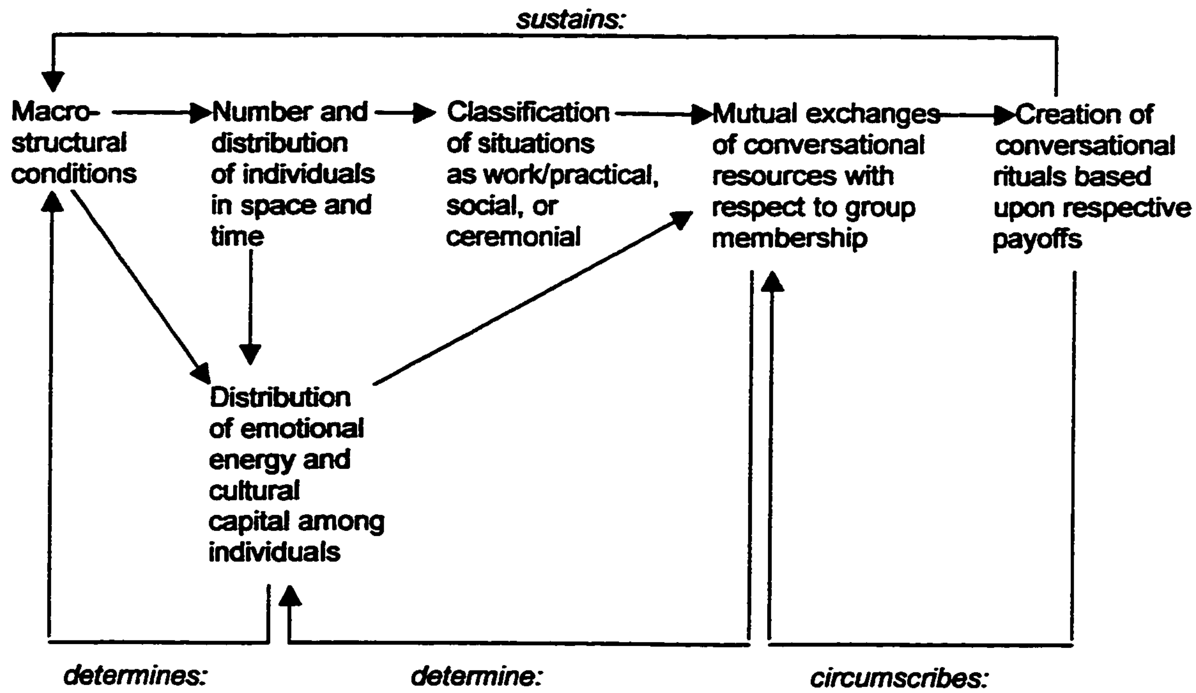


FIGURE A.11: Exchange-Ritual Model of Structuring

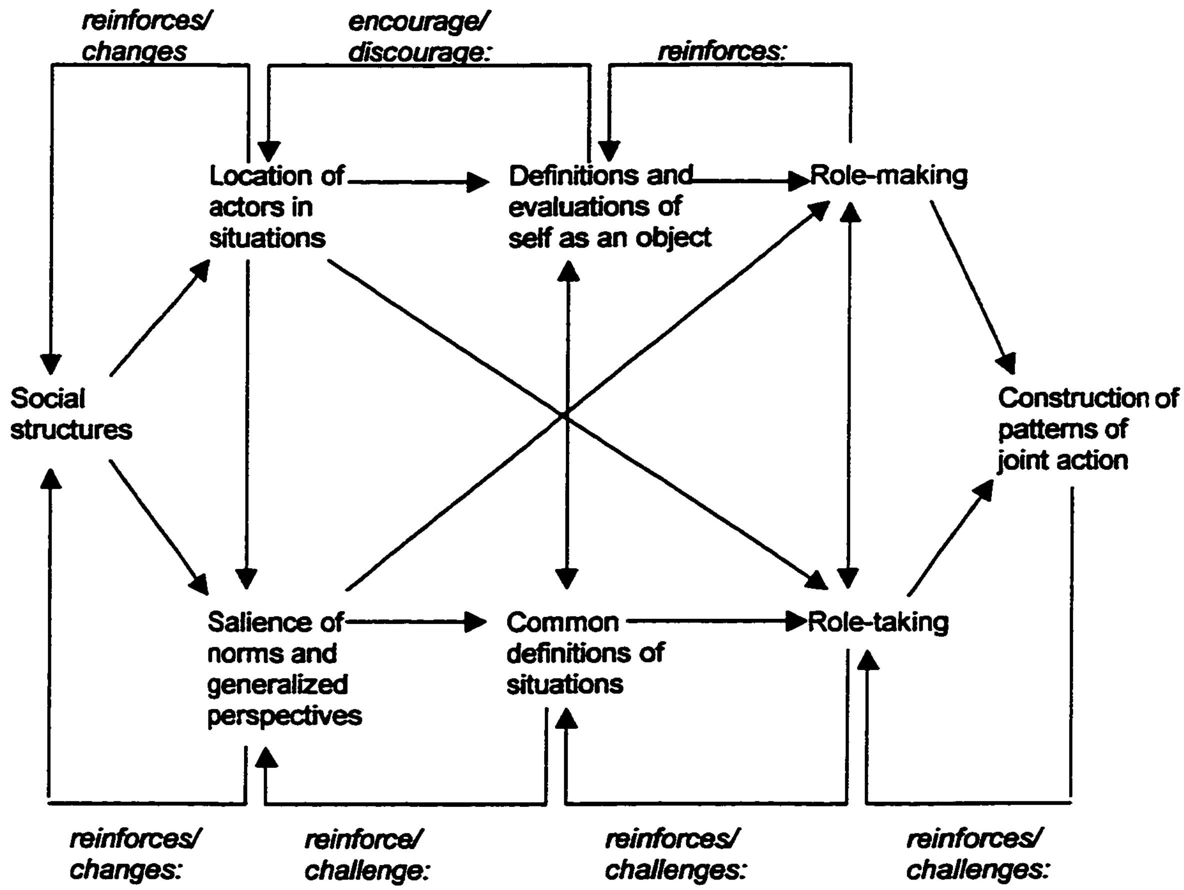


FIGURE A.12: Interactionist Model of Structuring

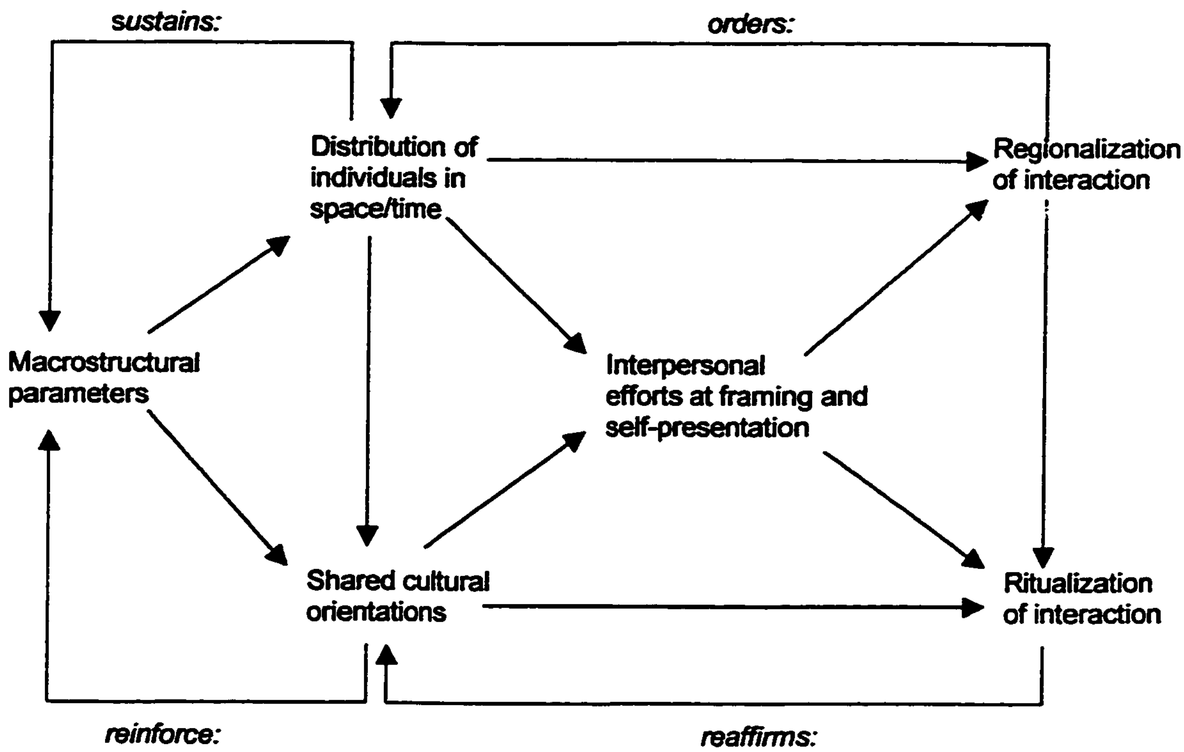


FIGURE A.13: Dramaturgical Model of Structuring

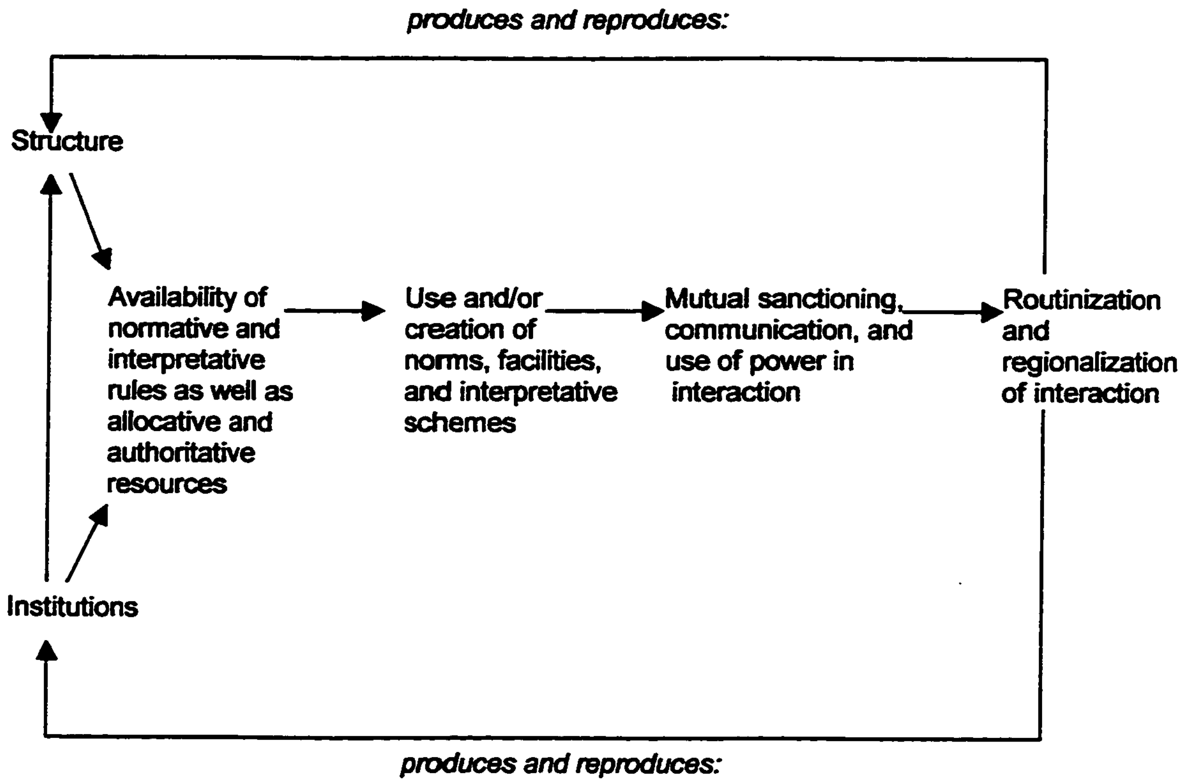


FIGURE A.14: Structuration Model of Structuring

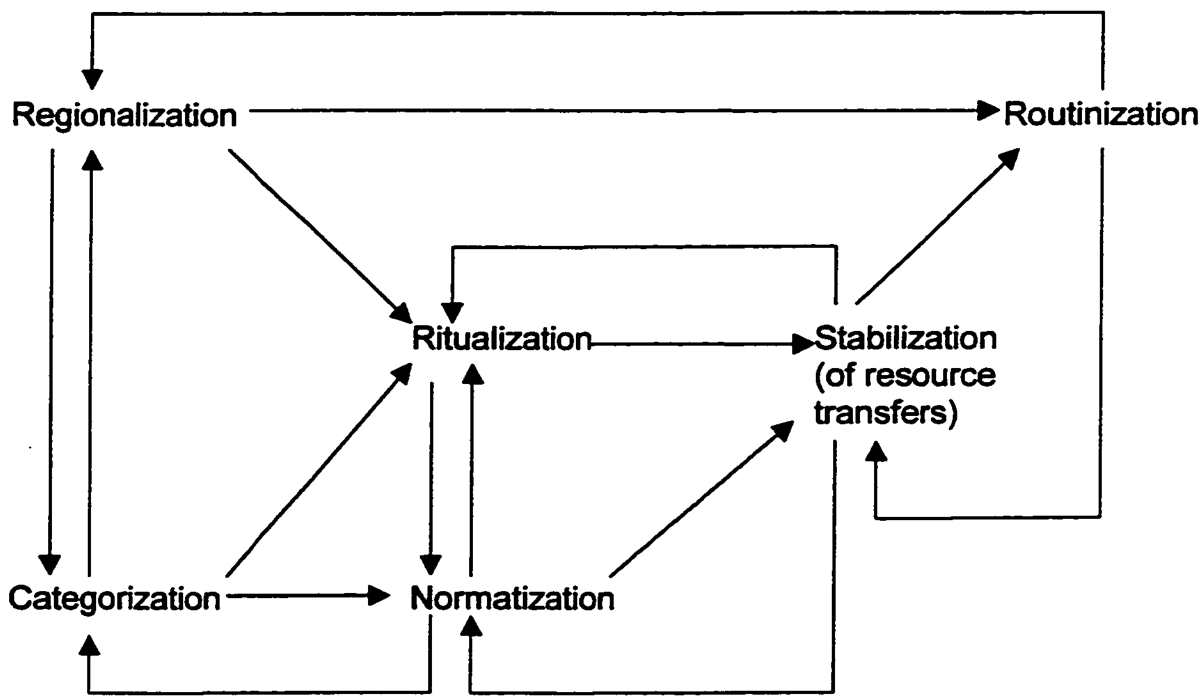


FIGURE A.16: Dynamic Model of Structuring Processes

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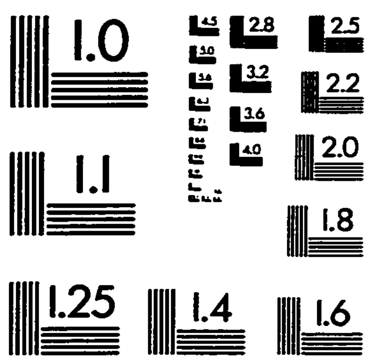
IMAGE EVALUATION TEST TARGET (QA-3)



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