CHAPTER 1

Why Emergence?

DESCRIBING EMERGENCE

Emergence is the creation of order, the formation of new properties and structures in complex systems. When emergence happens, something new and unexpected arises, with aspects that cannot be predicted even from knowing everything about the parts of the system. Emergence is studied in every field, from physics to philosophy. Physicists study emergent properties of molecules and forces, biologists study emergent behaviors of animal groups, sociologists study emergent structures in society, entrepreneurship scholars study the emergence of organizations. Emergence is one of the most ubiquitous processes in the world and yet one of the least understood.

Three examples shed light on some of the key issues in emergence. The first example is seemingly simple: the V-shape that is made by a flock of flying birds. The shape is emergent: it is not caused by any one bird's behavior, nor is there a leader in a flock. Instead, each bird individually is following simple rules that maximize its own efficiency in the group: (a) fly close together but avoid contact; (b) if you get too close, then separate; and (c) fly in the overall direction of the group. These rules, which guide the local actions of each individual bird, also lead to an emergent structure—the V that we see in the sky—which increases the efficiency of all the birds in the group.[1] The V is emergent because it is not caused by any one bird but by all the birds interacting together; the V is made up of all the birds but "transcends" them as well. In addition, the synergestic benefits allow the system much greater adaptability.

As another example, consider a natural ecosystem, like a forested area. Each of the parts of the ecosystem—all the different species of trees, plants, animals, insects, and so on—are at one level competing for their own survival and growth. Yet from a systemwide perspective all of these apparently independent organisms are *inter*dependent—they each need the others in order to survive and thrive in the ecosystem. This is important to understand, because it means that each pair of (inter)dependencies had to co-evolve—the entire system developed these relationships across networks, all at once over time. Further, the dynamic interactions and relationships across the entire ecosystem have generated a *resilience,* an increased ability of the system as a whole to support the organisms within it, for the long term. This systemic property of resilience is emergent, for it is not "in" any one element or species but arises through the interactions and relationships across all of them.

The same can be said for organizations as emergent systems. To the outside world, an organization *exists* as a distinct social entity: People perceive the organization as an agent in society—as a "person" in some sense. As an agent it "acts" in certain ways; it follows social rules, laws, and conventions, and contributes to the local community. But where "is" the organization in a tangible sense? The business is not "in" the individual employees, for all of them could be replaced without necessarily destroying the company. Nor is the organization "in" its managers or the founders, even though they heavily influence the firms emergence. The organization is not "in" the building (or website), nor is it "in" the individual exchanges that occur in person or online. Nor is the company to be found "in" its performance.

Thus, like the previous examples, *organization* is an emergent entity: it arises as a whole system, out of the combined interactions and relationships of elements, while not existing in any one of those elements. Likewise, the emergence process generates new opportunities and more energy than could be done by adding up all the activities of all of its parts—by a huge amount. Consider Adam Smith's calculations of the pin factory with an emergent division of labor, which was 1000% more efficient than the traditional model of making pins one by one.

Emergence is present at every level of reality. We encounter it, for example, in patterns of interaction that arise in our departments and workplaces, in the cultural norms that guide our behavior and expectations, and in the initiation of new projects and ventures. Emergence is also at the heart of complexity science—disciplines that use computation and nonlinear methodologies to explore the creation of order in the natural and social world.

Although more and more scholars are engaged in using complexity science and studying emergence, few people are aware of how many types of emergence have been being studied across the sciences, even the social sciences. To give some examples: Entrepreneurship researchers have been studying the emergence of new ventures,[2] the creation of new markets,[3] and the generation of regional clusters.[4] Organizational scientists are exploring emergence in group dynamics,[5] in the dynamics of innovation,[6] in the development and implementation of strategy,[7] in processes of change and transformation,[8] and in the creation of new institutions and industries.[9] Research in the psychological sciences has identified emergence processes in neurophysiology, cognition, and individual behavior.[10] Sociological studies have highlighted emergence dynamics in collective behavior.[11] Overall, the scholarship of emergence is dramatically expanding: the past 20 years has seen a 782% increase in research papers focusing on emergence within psychology, sociology, economics, education, and management.[12]

The same can be said for book-length treatises on emergence. In the social sciences, major contributions and compilations have been written by Stephen Guastello (1995) in psychology, Alicia Juarrero (1999) in philosophy, Harold Morowitz (2002) in evolutionary studies, Keith Sawyer (2005) in sociology, Clayton and Davies (2006) in physics and biology, Robert Reid (2007) in biological evolution, Bedau and Humphres (2008) in philosophy and the natural sciences, and Padgett and Powell (2011) in organization theory.

General introductions to emergence and complexity science have exploded as well, as evidenced in successful books by Michael Waldrop (1992), Roger Lewin (1992), Gell-Mann (1994), Kevin Kelly (1994), Bar-Yam (1997), Steven Johnson (2001), Strogatz (2003), Neil Johnson (2009), and Melanie Mitchell (2009). These, of course, take their place among many precursors, including Jantsch (1980), Depew and Weber (1985, 1994), Gleick (1987), Adams (1988), and Cilliers (1998), among others.

Overall, we have seen a dramatic increase in the pace and scope of writing on dynamic complex systems and the emergences they describe. However, up to now, each contribution has been separate: Few books on emergence build on previous work, and few emergence scholars refer to others in different fields. Likewise, almost all of the scholarly books on complexity science have focused on one or a few disciplines. For example, Kauffman (1993) focuses on NK landscape models; Holland (1995, 1998), on genetic algorithms; Prigogine (Prigogine & Stengers, 1984; Nicolis & Prigogine, 1989), on dissipative structures; Bar-Yam (1997, 2004), on mathematical and computational approaches; and Bak (Bak & Chen, 1991; Bak, 1996), on self-organized criticality. Although each of these works is definitive in its field, they each introduce only one aspect or perspective within the multilayered context of emergence.

The time is ripe for an integration of this work into a discipline of emergence. Such a discipline would organize all of the writing and research on emergence and complexity science into a single framework, which could serve as the basis for synthesis of and further insights across many levels of analysis. This book makes an important step toward that goal, by drawing together the entire range of empirical literature on emergence into a single framework of prototypes, identifying the complexity sciences that can be used to study it, and presenting an integrative definition of emergence in social systems of all kinds.

The first part of the book takes the broadest perspective by drawing on emergence research from physics, chemistry, computational science, agent-based modeling, biology, ecology, evolutionary studies, philosophy, psychology, sociology, and organization science. After the first three chapters, the rest of the book focuses on one of the eight fields in the discipline, namely generative emergence, which explores the dynamics of creation and re-creation of and in organizations, ventures, projects, initiatives, and social endeavors of all kinds. The core of the book is the five-phase process model of generative emergence, an approach developed over 30+ years of my own research, in concert and collaboration with many others.[13]

Why Emergence? Problems and Potentialities

For those with some familiarity with emergence, the concept adds a positive and unique view to our understanding of social innovation. Equally, generative emergence solves some long-standing problems in management and the social sciences and unlocks new potential in the complexity sciences. In particular, by highlighting the underlying processes of generative emergence we can:

(a) Explain the dynamics of emergence and re-emergence and how how they differ from the ontology of of organizational change and transformation. These dynamics may also reveal a new causal driver of organizational creation and social organizing.

(b) Resolve debates in entrepreneurship and organization science by differentiating between the *process* of emergence and its *outcomes* – emergence vs. emergents. .

(c) Expand the value and applicability of complexity science in management and other social sciences by showing how each of its 15 fields provides unique insights into emergence overall.

(d) Increase the rigor of applications in management by exposing the problems with using the phrase, self-organization.

(e) Synthesize a host of research across entrepreneurship, strategy, organizational behavior, innovation, and institutional theory, through a model of emergence organizing.

Each of these five objectives is briefly describe in the following sections.

Emergence and Re-Emergence vs. Change and Transformation

Among scholars who study how organizations grow and change, these processes are described in one of two ways: Organizational change occurs through incremental adaptations, whereas organizational transformation occurs through significant shifts in structures, systems, and processes (Bartunek & Moch, 1987; Gersick, 1991; Greenwood & Hinings, 1996; Weick & Quinn, 1999; Staudenmayer, Tyre, & Perlow, 2002). Thus, organizations can change by learning from their experience, and incrementally improving their situation (March, 1981; Quinn, 1989; Levinthal, 1991; Huber & Glick, 1993), or through transformation organizations can call into question one or more guiding assumptions and values, leading to a major shift in several aspects of the organization at once (Bartunek, 1984; Romanelli & Tushman, 1994; Bacharach, Bamberger, & Sonnenstuhl, 1996; Street & Gallupe, 2009). Except for recent new thinking from scholars like Eisenhardt, Garud, Rindova, and O'Mahony, among others, the extant models for internal-to-the-organization change revolve around these two poles.

Although some consider emergence to be simply another way to describe transformation; it is not—emergence is a totally different category from transformation and change, a third distinct process. At the root of this difference is the fact that every case of organizational change and transformation involves the *modification* of existing elements, an alteration of design structures or internal processes or activity routines in the organization. Like all path-dependent processes, the outcome crucially depends on the history of the system as well as the trigger for change; the possible outcomes are conditioned by the existing state and by what initiates the process.

In a similar way, virtually all management theories argue that the trigger for organizational change or transformation is a *crisis*—a growing problem or a pending catastrophe, that is reflected in a decrease in performance. The theoretical logic is that the company is not performing well (enough)in its domain, as shown by decling revenues or profits; thus change or transformation is necessary. According to this logic only a crisis is strong enough to dislodge the inertia of current operations; albeit risky the ensuing transformation should allow the organization to better match its environment, thus increasing its effectiveness and profits.

In contrast, emergence is significantly different from transformation. First, emergence is *creation,* not simply change. Emergence is the invention of something new, the origination of a distinct system and/or the structures within it. Consider again the V of a flock of birds. The emergent entity is not the result of a change; although the birds change, their changing is not what generates the emergent V. Nor can the V be explained as a transformation of the birds. Instead it represents a new creation, a "becoming" that was not there before its parts became interdependent.

A second difference is in the trigger for organizational emergence, which is *aspiration*[14]—the vision and enactment of a new opportunity to be capitalized on. Whereas crisis leads to a reactive attempt to save the organization, aspiration is an entrepreneurial desire to create new value, to make a new contribution to a community or within a market. For this reason, emergence and re-emergence are often initiated when nothing is wrong per se in the organization; they are not triggered by problems or urgent issues. And if so, they do so by turning the reactivity into procreative action. Thus the origin of emergence is a potentiality, a spark of creativity, an open-ended possibility that can be enacted in a myriad of ways. One of the benefits of aspiration is that it can generate a projected future that may have fewer constraints and more creativity for the organization.

Third, this spark of creativity produces a whole different set of behaviors than is likely in crisis-driven change. According to creativity scholars, problems and frustrations like those caused by crisis lead to “reactive creativity,” which is characterized by negativity and even a sense of desperation (Heinzen, 1994, 1999; Unsworth, 2001). In contrast, “proactive creativity” – the behavior from aspiration – is characterized by “intrinsic motivation, positive affect, and focused self-discipline” (Heinzen, 1994: 140). Research has shown that this prospective, problem-finding outlook is much more likely to spur useful ideas in organizations (Axtell et al., 2000) and to improve innovation more generally (Unsworth, 2001). Thus, the potentialities for emergence are greater than for transformation.

Finally, these greater potentialities are easily seen in empirical studies of emergence. Research shows that emergent structures expand the capacity of the system by an unprecedented amount, vastly increasing the capability of the system to accomplish its goals (Prigogine & Stengers, 1984; Swenson, 1988, 1989). Intuitively, this is evident in the three examples of emergence, each of which improves the efficiency, adaptability, and performance of their systems in ways that would be impossible through common modes of change. Thus, in all these ways, emergence and re-emergence are distinct from transformation, they provide many more avenues for an emergent system to gain creative innovation and dramatic increases in capacity. Much more about these findings will be presented in the following chapters.

Emergence as a Process with Multiple Possible Outcomes

A second problem that is taken up by generative emergence revolves around the two distinct meansings of emergence. In organization science, emergence has mainly been used to describe an emergent outcome—as for example in the emergence of ethical issues (Sonenshein, 2009), or in the creation of a proto-institution (Lawrence, Hardy, & Phillips, 2002) or the generation of new practice areas (Anand, Gardner, & Morris, 2007). In contrast, complexity scholars have explored the processes that lead to emergence (see, e.g., Chiles, Meyer, & Hench, 2004; Plowman et al., 2007a; MacIntosh & MacLean, 1999). In fact, some of this research proposes a series of sequential phases that lead to emergence, as exemplified in the work by Smith and Gemmill (1991), Leifer (1989), and Purdy and Gray (2009) and in my own work (Lichtenstein, 2000b, 2000d; Lichtenstein & Plowman, 2009). These differences reflect an uneasy question: Is emergence more of an outcome, or a process, or some of both?

This question has not yet been addressed, even with the growth of complexity science over the past 20 years. As one example, the long-standing focus of computational models is on the structure—the emergents—of the agents in the simulation (Levinthal & Warglien, 1999; Gavetti & Levinthal, 2000; Fleming & Sorenson, 2001; Gavetti, Levinthal, & Rivkin, 2005; Ganco & Agarwal, 2009). For example, NK landscape models (Kauffman, 1993) have identified stable patterns of interaction that emerge between interacting, interdependent heterogeneous agents. In contrast, there has been far less emphasis in the field on the underlying dynamics or processes that spark emergence.

Thus, the book presents numerous insights that can be gained by considering emergence as a process with a range of emergent outcomes. Specifically most of this book is dedicated to exploring the processes and dynamics of emergence, especially the ways in which these dynamics are expressed in five distinct phases. Other aspects of the book focus on the range of emergents it can generate—from no emergent to first-degree, second-degree, or third-degree emergents.

Another benefit of considering emergence as a process with outcomes is that the dual construct can potentially resolve two debates in organization science, which I will mention here briefly.

The first debate is based primarily in entrepreneurship, but it affects strategy and innovation as well. The question is whether business opportunities are primarily "objective," existing independent of an entrepreneur who may discover them, or "subjective" or "creative," coming into being through their enactment and organizing. This debate is quite current, as shown by the January 2013 Dialogue section in the *Academy of Management Review* (Vol. 38, #1). There, four sets of authors present alternative views regarding the existence and realization of opportunity. In particular, according to the "discovery" approach, opportunities are an outcome, the result of conditions and constraints in technology, markets, and entrepreneurs. According to the "creation" approach, opportunities are an emergent process; a viable opportunity is one that becomes increasingly visible through entrepreneurial organizing and enactment. An emergence perspective provides a unique integration by viewing opportunities as emergents (perceivable social entities) that are, and can be, enacted. As will be explained in depth in Chapters 8 and 10, the resolution is based on a different distinction, namely the degree to which an entrepreneur experiences what I am calling "opportunity tension" (Lichtenstein, 2009). In this formulation, the focus is on an interaction between the opportunity—whether "objective" or "enacted"—and the "creative tension" of the entrepreneur (Fritz, 1989). Together, these drive the emergence of new organizations and ventures, the catalyst of social innovation and creation.

The second debate is the long-standing query into the resources, qualities, or conditions that lead to organizational emergence. This question has been asked by entrepreneurship scholars in terms of the activities that give rise to new ventures (Delmar & Shane, 2003, 2004; Brush, Manolova, & Edelman, 2008), the resource endowments that lead to a successful start-up (Cooper, Gimeno-Gascon, & Woo, 1994; Brush & Greene, 1996; Reuf, Aldrich, & Carter, 2003), and the environmental conditions that mediate business creation processes (Aldrich & Fiol, 1994; Schoonhoven & Romanelli, 2001; Almandoz, 2012). In the emergence perspective these questions are one-sided; they miss the fundamental contribution provided by the *process* of emergence. For example, our study (Lichtenstein, Carter, Dooley, & Gartner, 2007) showed that it did not matter *what* the entrepreneur did; the likelihood of emergence depended solely on the dynamics of the organizing process. Specifically our findings, based on a non-linear analysis of the Panel Study of Entrepreneurial Dynamics (PSED), showed that the content of entrepreneurial activity did not influence success; instead the likelihood start-up was predicted solely by the temporal dynamics of entrepreneurial action—the rate, pace, and quantity of effort. In these ways emergence may allow researchers new ways to focus on the underlying processes of organizational creation. Adding these dynamics to our knowledge base may also spark new research into organizational growth and change.

Expanding the Potential for Complexity Science

A third issue taken up by the book refers to the assumption made by most people that research using complexity science refers to a type of computational study. That is, current perceptions in the academy are that the only way to explore order-creation in complex systems is through computation and agent-based modeling. This bias is clear in the scholarly reviews of complexity in organization science, which treat the study of complex systems and emergence as a computational issue (e.g., Cowan, Pines, & Meltzer, 1994; Anderson, 1999; Axelrod & Cohen, 2000; Sorenson, 2002; Prietula, 2011). The same can be said of popular summarizes (Johnson, 2001; Downey, 2009; Johnson, 2009; Mitchell, 2009).

Further, the predictive power of NK landscape research has made it into a premier methodology, as is easily seen by the increasing volume of top-tier publications (Levinthal, 1997; Levinthal & Warglien, 1999; McKelvey, 1999a; Gavetti & Levinthal, 2000; Rivkin, 2000; Sorenson & Audia, 2000; Ararwal, Sarkar, & Echambadi, 2002; Rivkin & Siggelkow, 2003; McKelvey, 2004c; Gavetti et al., 2005; Siggelkow & Rivkin, 2005, 2006; Sorenson, Rivkin, & Fleming, 2006; Rivkin & Siggelkow, 2007; Porter & Siggelkow, 2008; Ganco & Agarwal, 2009; Sommer, Loch, & Dong, 2009). Clearly the methods are successful and provide knowledge that is consonant with mainstream management thinking.

However these computational studies in complexity science were not at the origin of the field, nor have they been the most common. Much of the early work on emergence in management was based on applications of Prigogine's work in thermodynamics (e.g., Odum & Pinkerton, 1955; Odum, 1969; Allen, 1982; Prigogine & Stengers, 1984; Wicken, 1985, 1986; Allen & McGlade, 1987; Adams, 1988; Dyke, 1988; Goldstein, 1988; Odum, 1988; Wicken, 1989; Depew & Weber, 1994; Juarrero, 1999; Morowitz 2002; Schneider & Sagan, 2005). These studies explored the underlying dynamics of order creation, but most of these researchers are virtually unknown to the current generation of complexity scholars.

Moreover, computational methods have limitations that are rarely expressed but are important to reveal. One broad problem with computational models is their reliance on effects that are programmed into the agents, rather than being truly emergent results of their interactions. Sawyer makes the strongest case for this issue (2004, pp. 164-165):

> First, the macrostructures or macroproperties do not themselves emerge from the simulation but are imposed by the designer. Yet in actual societies, macrophenomena are themselves emergent from microprocesses. . . . A second problem in applying these multilevel artificial societies to sociological theory is that agents do not have any perception of the emergent collective entity (Castelfranchi, 1998; Conte et al., 1998; Servat et al., 1998). In the CORMAS simulation, agents do not know that they are being taxed, nor that a quota has been imposed. In the EOS simulation of group formation . . . no agent has awareness of its own group as an entity, and agents that are not in a group have no way of recognizing that the group exists or who its members are.

Another important limitation of computational models is a recent strong critique of the NK landscape methodology developd by Kauffman (1993) and extended by Levinthal, McKelvey, and others (e.g., Levinthal & Myatt, 1994; Levinthal, 1997; Levinthal & Warglien, 1999; McKelvey, 1999a, 1999b; Ganco & Agarwal, 2009; Sommer et al., 2009). Specifically, McKelvey and his collaborators (McKelvey, Li, Xu, & Vidgen, 2013) pursued an in-depth theoretical analysis of the NK model and found two important problems. First they noted that the theoretical roots of the NK model in genetic biology and bioecology, are based on the assumption that connections between agents will be *epistatic*, that is, agents are connected to each otherh through strong-tie effects. In contrast however, they point out that most of the ties between members of an organization are weak ties. In the same way, often the most powerful connections in social networks are made through weak ties (Granovetter, 1973; Obstfeld, 2005). This leads to a challenge:

> As far as we know, then, genes cannot turn epistasis on or off. But employees in firms can—they can choose how and when to interact with other employees. . . . But if employees can turn their interactions on or off, then the Kauffman-designed NK model clearly offers unrealistic simulations of organizational phenomena. [Thus we] challenge the NK-design as *not* being broadly applicable to organizations, as current applications of the NK model generally presume. (McKelvey et al., 2013, p. 8)

Added to this theoretical challenge is a more complicated one based on their mathematical analysis of the underlying NK algorithms. They conclude:

> NK-model results appear to be artifacts preordained by the code rather than by theory-based experiments. . . . Consequently, "moderate complexity"—i.e. when K is neither zero nor large—always wins.

Given that this is true in virtually all NK models, their critique of the method is intriguing and unsettling. While not invalidating the importance of computational modeling, it does give pause to the applicability of these results for management, an issue explored further in Chapter 2.

Of course, we know that computational modeling is not the only type of complexity science; many scholars have identified the wide range of complexity sciences. Goldstein (1999, 2000), for example, mentions nearly a dozen disciplines of complexity science in his introductions to its history and foundations. Maguire and his colleagues (Maguire, McKelvey, Mirabeau, & Oztas, 2006) identified 25 disciplinary origins of complexity science and framed a very wide spectrum of complexity contributions in four broad categories. These integrations are supported by the earlier work of McKelvey (2004c; Andriani & McKelvey, 2009) in his distinction between the American school of complexity, centered at the Santa Fe Institute and which emphasizes computational studies, and the European school of complexity, which is grounded more in the natural sciences' explorations of emergence and order creation.

Overall, my approach is to claim that dissipative structures theory is a very good alternative to computational modeling as a core metaphor for organizational emergence, a claim that is supported by my analysis in Chapters 7 and 8. As will be shown in Chapters 16, 17, and 18, the model provides many useful insights to organization science, findings and perceptions that complement the computational work. Through this complementarity a new generation of effective and relevant complexity science research could be generated.

Problems with "Self-Organization"

A fourth problem that generative emergence aims to solve is related to the popular term for emergence, namely *self-organization*. Many of the original applications of complexity science in management were based on the idea of self-organization; for example, in the early 1980s two edited books (Schieve & Allen, 1982; Ulrich & Probst, 1984) applied self-organization to understanding population dynamics (Zurek & Schieve, 1982), urban systems (Allen, 1982), and economics (Davidson, 1982). Smith's work on self-organization (Gemmill & Smith, 1985; Smith, 1986; Smith & Gemmill, 1991; Smith & Comer, 1994) extended these ideas into organization behavior and management. Over the past 15 years, a host of management scholars have invoked the term *self-organization* in papers on the following topics:

- Leadership (Guastello, 1998; Lichtenstein, 2000c; Zaror & Guastello, 2000; Plowman et al., 2007b)
- Innovation and learning (De Vany, 1996; Saviotti & Mani, 1998; Lichtenstein, 2000c)
- Market economics (Lesourne, 1993; Lesourne & Orlean, 1998; Foster, 2000)
- Entrepreneurship (Zuijderhoudt, 1990; Buenstorf, 2000; Lichtenstein, 2000b; Biggiero, 2001; Lichtenstein & Jones, 2004)
- General management (Adams, 1988; Salthe, 1989; Zohar & Borkman, 1997; McKelvey, 1999b; Contractor et al., 2000; Gunz, Lichtenstein, & Long, 2001; Ferdig & Ludema, 2005)

Such applications remain common in even the most recent work (e.g., Butler & Allen, 2008; Saynisch, 2010; Tapsell & Woods, 2010; Stevenson, 2012; Wallner & Menrad, 2012). Although self-organization is a popular term, there are two problems with its use which I summarize briefly.

Lack of Rigor in Applications of Self-Organization and Complexity

First, self-organization is often used as a metaphor than as a carefully specified scientific process. That is, with numerous exceptions mentioned later in this chapter, applications of self-organization are often developed with an eye to training and consulting advice, rather than being linked to rigorous science. This point was clearly made in an early analysis of the diffusion of complexity science, the first wave of business applications, by Maguire and McKelvey (1999) in a special issue *Complexity Applications in Management,* in the journal *Emergence* (Vol. 1, #2). They summarized the problems with many management consulting books in the 1990s, which ostensibly used complexity and self-organization to understand organizations, by concluding that most books suffered from

> loose, less than rigorous, oversimplified, and even sometimes incorrect use of concepts. And while metaphors are applauded, a number of reviewers feel that authors' over-reliance on metaphors contributes to these superficial treatments. The absence of at least some mathematics in many books is conspicuous and undesirable for a number of reviewers, as is also the insufficient harnessing of simulations and computer models. . . . Finally, although empirical examples are much appreciated, a number of reviewers feel that these are mere retellings of old tales using complexity terminology tacked on retrospectively, gratuitously and, in many cases, quite awkwardly. (Maguire and McKelvey, 1999, p. 23)

Fortunately, not all applications of complexity are loose and oversimplified; indeed, most complexity science research in organization science journals is tightly connected to its disciplinary foundation. Such studies are based on rigorous and often testable analogies to one of the underlying sciences of complexity. Likewise, many practitioner applications reveal very strong analogies. For example, the *MIT Sloan Management Review* special issue *In Search of Strategy* (1999) included two exemplars of rigorous complexity applications. Pascale (1999) reviewed "four bedrock principles" from the science of complexity, drawing on the work of Prigogine, Holland, and Kauffman. He then used those to identify four operational assumptions that underlie a more adaptive approach to strategy. Similarly, Beinhocker (1999) developed a careful analogy from adapting agents in an NK landscape theory to adapting organizations in a competitive landscape. Like many scholars who have made this link—but unlike most of his consulting colleagues who lack the necessary rigor—Beinhocker reviewed the underlying framework of NK landscape simulations and then made three strategic directives that are actionable applications of known experimental results.

Even so, this rigor is rarely found in articles that emphasize self-organization. This raises the first challenge to the term, namely the inherent difficulty of making rigorous analogies between that self-organization (see Chapters 3 and 6) and organizational behavior. Still, beneath that challenge is a more fundamental issue—namely, the locus of agency in self-organization.

Is Self-Organization as Simple as It Seems?

Most studies of complexity examine the "bottom-up" emergence of agents into higher order entities. These studies of self-organization permeate the computational fields of complex adaptive systems theory (Holland, 1995, 1998), genetic algorithm models (Axelrod, 1997; Axelrod & Cohen, 2000), and agent-based models (Epstein & Axtell, 1996; Sawyer, 2005). The problem is that all of these models present agents as relatively simple learning entities, which operate according to one or a few "simple rules." Likewise, these simulated humans only interact with local (proximate) others. These studies are able to find bottom-up emergence, that is, the creation of order solely through local interactions with no external influence or top-down control. As Clippinger (1999, p. 6) explains, "No one unit [agent] has any plan or even goal concerning how the overall system should act, and yet the system evolves into a complex structure adapted to its circumstances. . . . Because complex systems adapt from the bottom up, there is no way of planning for change."

Although this is a compelling description, does it reflect real and emergent behavior in social systems? Do emergent systems always act "of their own accord"?

Jeff Goldstein (2000) is especially clear about the problems with this perception that self-organizing can occur spontaneously. He notes that this interpretation of self-organization leads to a mistaken belief that

> novel structures would somehow emerge in organizations if only the "command and control" hierarchy would be dismantled in favor of individual action. This misinterpretation led to a spate of management books pushing for "self-organizing" as a form of laissez-faire leadership, [i.e.] that somehow relaxing managerial control would inevitably lead to "self-organization" to solve the organization's problems. (Goldstein, Hazy, & Lichtenstein, 2010, p. 80)

At least three issues are at play here. First, from a leadership perspective, Mary Uhl-Bein and her colleagues (Uhl-Bien, Marion, & McKelvey, 2007; Uhl-Bien &

Marion, 2008) have shown that even if some organizing is motivated by purely bottom-up actions, this is always balanced in formal organizations by bureaucratic as well as adaptive leadership. Together these three factors provide the necessary strategies, resources, and decision-making context for so-called self-organizing activities. These additional layers of complexity highlight the limitations of computational agents, which can be programmed to follow only a specific number of rules and which interact only with proximate neighbors. In contrast, real managers would be very hard pressed to instill such constraints on their subordinates!

Second, from an empirical perspective, studies of order creation using computational models have revealed at most four "levels" of activity in an organization—individual agents, teams, sets of teams, and some executive functioning (Lichtenstein & McKelvey 2011; see also Lichtenstein 2011b). Even the most sophisticated of these 'self-organized' models lead to simple organizations with a CEO and two layers of management; however our business world is filled with organizations that encompass five, six, seven, and more layers. Bottom-up organizing alone is unable to generate this complexity (Lichtenstein & McKelvey 2011).

Equally important, it turns out that so-called self-organization is far from spontaneous and lacking in control structures. Instead, in all of the formal experiments that reveal self-organization, the outcomes are possible only because of constraints, containers, boundaries, and external structures, an insight developed by Goldstein (2011):

> A careful reading of the experiments and instances of self-organization reveals they are replete with a legion of *non*-spontaneous *constraints* that

> far out-number and far exceed in significance any appearances of spontaneous processes. (Goldstein, 2011, p. 98, his emphasis).
> Open systems—like organizations—do have the capacity for self-organization, but only when they are constrained in specific ways and when there are the requisite flows of energy, resources, and information through the system and across its boundaries. (Goldstein et al., 2010, p. 80)

Recent innovations in complexity science have been exploring the issue of spontaneity by emphasizing the agency of individual agents within the social ecology. Further, researcher are investigating how agency can catalyze social innovations and emergents in ways that are both spontaneous and planned, emergent and constructive. Such applications, when developed through rigorous analogical maps, can tell us much more than was possible in the original work on self-organization.

Overall, my claim is that the term *self-organization* was useful at the beginning of complexity science, but now it is freighted with too many loose applications and theoretical confusion. As a result, I do not use that term at all in this book.[15] Instead, I turn back to its origins in dissipative structures theory carefully distinguishing between the dynamics of the emergence process and the possible emergents that accrue.

Integrate Research Through a General Model of Emergence

A final benefit of generative emergence is in its potential to offer a general model of emergence across multiple fields. This reflects the fact that there is already a very wide range of research on emergence in the social sciences, from applications in cognitive science to studies in leadership, organizational behavior, groups, entrepreneurship, organizational design, strategic change, collaboration, networks, economic geography, regional development, and sociology. See Table 1.1 for examples at each of these levels (unit of analysis).

[Insert Table 1.1 here]

Given this broad range one might wonder what connections could be made between the emergence of, for example, group norms, the "self-organization" of entrepreneurial networks, the self-renewal of large corporations, the emergence of ethical issues, the emergence of new markets, and the emergence of institutional fields, to name a few. It turns out that a general model of emergence reveals parallel dynamics across all of these studies.

In particular, connections across these fields are relatively easy to make with the use of the five-phase process model of emergence, presented in Chapter 7, and the continuum of emergent outcomes (Chapter 8). In particular, the process-based model allows researchers to make links across multiple units of analysis, such that insights from one level might be applied to others. Overall, this supports my claim for a discipline of emergence, with frameworks that cut across levels of analysis and even across supposedly separate fields of organization science, psychology, sociology, and so on. This approach has already been shown to integrate studies within organization science (Lichtenstein & Plowman, 2009) and to organize a myriad of studies in entrepreneurship as well (Lichtenstein, 2011a, 2011b).

Last, embedded in the emergence model is a general framework for organizing at all levels—that of dynamic states—developed by Levie and Lichtenstein (2010) and drawn out in Chapter 8. It is complementary and has important parallels to the approach taken by Padgett and Powell (2011). It also enables links to a host of other research in the areas of ecological resilience (e.g., Baldwin, Murray, Winder, & Ridgway, 2004; Folke et al., 2004; Liu et al., 2007), sustainability (Buenstorf, 2000), bioeconomics (McKelvey, 2004b; Foster, 2011), and perspectives on organizational evolution (Rosser, 1992; Foster & Metcalfe, 2012). Here again, emergence can become an integrative frame that connects previously divergent literatures.

In summary, a disciplinary approach to emergence leads to a number of important insights. First, emergence is distinct from organizational transformation, being initiated by aspiration and opportunity rather than by crisis, and which generates new capacity in the system. Second, distinguishing the process of emergence from its outcomes solves some long-standing debates in entrepreneurship and organization science. Third, extending our understanding of emergence through complexity science reveals a much broader set of methods and approaches than are usually acknowledged in complexity-based applications, which increases the potentiality for a discipline. Fourth, with these shifts comes a much more rigorous explanation of self-organization, one which is true to the underlying science and integrates with a broader range of empirical findings. Finally, this integration is part of a general theory of emergence that incorporates a five-phase process model and a range of emergent outcomes; the general model allows for a synthesis of much previous work across multiple fields across the social sciences.

SUMMARY OF THE BOOK

These benefits are gained through a series of arguments that extend throughout the book. Understanding the entire scope up front will offer a valuable point of reference for each part, and provide some guidance for where different readers may want to focus their attention.

The book begins with a proposal for a formal discipline of emergence that draws together insights from emergence scholars in the natural sciences, philosophy, and the social sciences. As a start, I suggest a set of prototypes of emergence (Chapter 2), I survey the extant methods for studying emergence (Chapter 3), and I offer an integrative definition for my main field of interest, generative emergence (Chapter 4). In addition I review the types of emergence being studied in organization science (Chapter 5). Academics in all fields should find these chapters intriguing.

Ultimately my goal is a highly rigorous, empirically driven map of generative emergence, an approach that is especially useful for social scientists. This starts with a careful examination of dissipative structures (Chapter 6), which reveals a specific process of emergence as well as experimental conditions for emergence. The process is then applied to organizations as a five-phase model (Chapter 7); separately the distinct conditions of generative emergence lead to a general model of dynamic states (Chapter 8). Last, the four outcomes of generative emergence are presented (Chapter 9). These chapters are well suited to social scientists, including scholars and PhD students in entrepreneurship, management, organization theory, and policy studies.

At the core of the book is a full description of the five phases of generative emergence, through an in-depth presentation of re-emergence in entrepreneurial ventures (in Chapters 10, 11, 12, 13, and 14). Added to this is a theoretical claim for cycles of generative emergence and re-emergence (Chapters 15 and 16), a claim supported by several additional case studies. This segment of the book is well suited to entrepreneurs and professionals who seek tangible examples of emergence, as well as researchers and academics who want to pursue further study in these dynamics.

Finally, the last two chapters offer an aspiration for future work. While identifying the "boundaries" of generative emergence, I make some broad suggestions about studying emergents that are "beyond those boundaries" (Chapter 17). Then I make some untested claims about enacting emergence in organizations and society as a whole (Chapter 18).

Although I've designed the book such that readers can start with any of these four parts, their import is best understood with reference to the argument as a whole. Thus what follows is a chapter-by-chapter summary, which will explicate the entire scope of generative emergence.

Chapter 2. Prototypes of Emergence

Making a claim for a discipline of emergence requires first that all of the different types of emergence can be identified. Although a complete list is nearly impossible to find in the literature, Chapter 2 begins by citing over 20 types of emergence that have been explored through physics, chemistry, computer science, biochemistry, biology, entomology, ecology, evolution, anthropology, sociology, linguistics, group dynamics, entrepreneurship, institutional theory, and economic geography.

All of these types can be organized into a single framework, one which is comprehensive yet parsimonious. My proposition is to present eight distinct prototypes of emergence—each being a basic form or archetype of order creation.[16] These prototypes incorporate the entire range of emergents in the physical, computational, biological, and social world. In the briefest summary, the prototypes are as follows:

I. **Relational properties,** such as temperature, pressure, and viscosity. These are systemwide properties that “emerge” out of the interactions of massive numbers of molecules in closed containers.

II. **Exo-organization.** When high energy is directed (pushed) into a contained system, the result can be creation of new degrees of order. Examples are laser light and dissipative structures; both are emergent structures that emerge in far-from-equilibrium systems.

III. **Computational order** refers to ordered patterns and stable structures that arise across computational agents. These structures are not directly programmed into the system but emerge solely due to “simple rules” for action and interaction that are programmed into each agent.

IV. **Autocatalysis** refers to self-generating networks of interaction within chemical or biological systems. Once initiated, the reactions across the network produce the catalysts that spark the set of reactions, producing a self-reinforcing emergent entity.

V. **Symbiogenesis** occurs when one organism envelopes another to create a new biological form. The classic example is the creation of the eukaryotic cell through the enveloping of mitochondria within it. Here, the emergent is over 1,000 times more effective at photosynthesis and other cellular functions than its prokaryotic precursor.

VI. **Collaborative emergence.** Dynamic structures arise through the interaction of many agents (organisms) that are guided by simple rules; examples include termite hills, traffic patterns, and the *V*-form in bird flocks. Another form of this is stable social emergents (Sawyer, 2004), which include slang words, global brands, and collective memory. As well, this prototype explains the emergence of institutions—material, social, and legal systems structured through shared cognitive frames. In each case, the higher-level emergent is an unplanned result of purely local interaction.

VII. **Generative emergence.** Social entities arise and remain stable through intentional creative agency and organizing. An entity (e.g., an organization) emerges through an aspiration—partly planned and partly evolving—to provide some kind of value, that is, a product, service, or offering that is valued by other agents (individuals). This offering is exchanged for money, which is then used to maintain the entity. Generative emergence is ubiquitous in society, being the basis for all businesses, companies, projects, initiatives, and innovations.

VIII. **Collective action,** a more macro form of generative emergence, refers to collaborative organizing processes that can lead to large-scale creation and change in society. Collective action has been explored by scholars of institutional entrepreneurship and by social movement theorists.

In sum, the prototypes provide a framework that allows us to view a much broader range of emergence than has been presented in most other complexity-science texts, a framework that allows for a discipline of emergence. At the center of this discipline is generative emergence, a form that until now has not been identified as a type of emergence. By understanding the nature of generative emergence, we can gain insight into the creation and sustaining of all kinds of social entities. Such an understanding requires a shared knowledge about complex systems and how to study them—the topics of the next chapter.

Chapter 3. Methods for Studying Emergence—15 Fields of Complexity Science

The origins of complexity science lie in 50+ years of research into nonlinear dynamics in the fields of mathematics, physics, biology, information science, and system dynamics, to name a few. Following numerous researchers who have argued for an inclusive definition of complexity, this chapter presents the entire range of complexity science in terms of 15 fields. Each of these fields has its own theoretical frame and analytic methodology, and a set of applications in organization science and other social science disciplines. All of them offer a unique and nonlinear perspective for understanding complex dynamic systems.

Some of these fields are more well-known than others. For example, NK landscape models are familiar from the work of Kauffman (1993), Levinthal (Levinthal & Warglien, 1999), and McKelvey (1999a). In contrast, few researchers have used autopoiesis (Maturana & Varela, 1980) or its related theory of autogenesis (Csanyi & Kampis, 1985; Drazin & Sandelands, 1992), although Padgett and Powell (2011) base their examination on these fields. No other text has presented this entire scope of complexity science.

The 15 fields of complexity science are presented in Table 1.2

[Insert Table 1.2 here]

In full, Chapter 3 presents the theoretical and scientific origins of each field and suggests how the discipline has been used to contribute to our understanding of emergence. As a whole, these descriptions offer a comprehensive toolbox for social scientists interested in studying emergence.

Chapter 4. Defining Emergence and Generative Emergence

To round out the idea of emergence as a discipline, I turn to a formal definition, which draws on the best work I have found in philosophy and philosophy of science, evolutionary studies, sociology, and organization science. The result is a definition that summarizes decades of discourse into five distinct qualities of emergence. Specifically, these qualities allow one to assess whether a particular phenomenon is strongly emergent (Bechtel & Richardson, 1992; Corning, 2002; Bar-Yam, 2004; Ryan, 2007), meaning that the emergent has properties or structures that are separate and essentially autonomous from the components that make it up.

Based on the analysis presented in the chapter, an entity or phenomenon is emergent (in the strong sense) if it expresses these qualities:

1. **Qualitative novelty,** meaning that its properties *transcend* its components, producing outcomes that are unpredictable and surprising even with a full understanding of the components. The *V*-shape of flocking birds expresses this well.
2. **Nonreducibility,** meaning that the emergent properties cannot be reduced or explained solely by the system's components, nor to their interactions alone. An example from biology is a cell—a living entity that cannot be explained by examining all of its separate components on their own.

3. **Mutual causality,** such that the components influence the system as a whole (upward causation), and the emergent properties have causal impact on the components (downward causation). A social example is a small organization, which is impacted by the actions of each of its employees, but which has systemwide qualities that influence and affect the behavior of all of its members.
4. **Structioning,** which refers to a kind of co-creative interchange between *agency*, the drive and motivation within the system, and the *constraints* of the system, the boundaries and limitations of the container itself. An example is laser light, which is formed through an interchange between the electrical energy being forced into the system and the mirrored walls of the container which contstrain that energy, allowing it to build to a threshold wherein a new, high-energy form of light is produced.
5. **Capacity is increased,** whereby the outcome confers greater efficiency, efficacy, and power to the components of the system and to the system as a whole. Many examples are presented here and in Chapter 6.

When all five qualities are present in an emergent, the outcome is defined as strong emergence, or more broadly it reflects generative emergence. This definition provides a philosophical grounding for the discipline of emergence and sets the stage for a review of how emergence has been defined and explored in management and the social sciences.

Chapter 5. Types of Emergence Studies

A close look at the literature reveals that emergence studies tend to cluster around one of four types or styles, each of which corresponds to an aspect of emergence that is being studied. These types are complexity metaphors, complexity descriptions, complexity models, and generative complexity.

Complexity metaphors use figurative language to draw attention to certain patterns in social and organizational systems. *Complexity descriptions* go further by measuring or discovering an emergent, usually through post-hoc quantitative analysis. *Complexity models* are formal or computational systems that enact emergence through computer simulations or agent-based programs. *Generative complexity* refers to dynamic systems with emergents that actually generate greater capacity for the system as a whole.

All four of these types are needed for a complete understanding of emergence. At the same time, generative complexity provides explanations that are especially useful in the context of generative emergence. With this in mind, the book focuses more directly on generative emergence, starting with an examination of its underlying field, dissipative structures.

Chapter 6. Dissipative Structures

Of all the 15 fields of complexity science, dissipative structures is ideal for studying generative emergence because the "order-creation dynamics" at its heart are highly applicable to organizations, ecosystems, and all social entities. Perhaps for this reason, they have been used by so many researchers to explain transformation, innovation, and action in organizations[17] and across organizations,[18] as well as in psychology, economics, education, and history.[19] In formal terms, the order-creation dynamics of this field capture the tangible behavioral qualities of generative emergence.

The most well-known experiment in this discipline, the Bérnard experiment, was explored deeply by Prigogine and his collaborators (Prigogine, 1955; Prigogine & Glansdorff, 1971; Prigogine & Stengers, 1984; Nicolis, 1989; Nicolis & Prigogine, 1989). In the Bérnard experiment, a viscous fluid is heated from a source at the bottom of a round, low container; normal conduction currents dissipate the heat, which is drawn out of the container through a sink at its top. Increases in heat energy can be assimilated, up to a point. But if the amount of heat energy is increased beyond a critical threshold, the fluid will experience a change of state—what Prigogine described as the onset of "self-organization." At this point, the molecules across the entire container will organize themselves into stable structures which from above look like hexagons. These hexagonal structures dissipate far more heat energy than conduction currents can.

The second experimental paradigm of dissipative structures is a "chemical clock" known formally as the B-Z reaction. Here, with the right reactants, a far-from-equilibrium chemical system can generate its own autocatalytic reactions. At that point the system exhibits systemwide shifts—oscillations like a clock—whereby the entire system changes from one color to a different one and back again. An analysis of both experiments reveals numerous parallels in their processes:

1. Once initiated, the system can move into a far-from-equilibrium state.
2. Nearing a threshold, fluctuations (turbulence) arise throughout the system.
3. At the threshold, the system exhibits nonlinearity as well as bursts of amplification.
4. The emergent order that happens is a recombination of existing elements in the system.

5. Emergent order remains stable, even when perturbed.

In terms of outcomes, the two experiments reveal the following:

a. Emergent order increases the capacity of the system to a large degree.

b. Following the basic tenets of multilevel systems, the emergent order transcends but includes its components.

It turns out that these processes and outcomes can be applied to organizations; they describe the process of generative emergence.

Chapter 7. Applications to Organizations

Although many researchers have tried to make a direct (mathematical) parallel between thermodynamics and economics,[20] I take a more moderate approach by pursuing an analytical mapping of dissipative structures onto order creation in organizations. Following the science (in Chapter 6), this rigorous mapping approach reveals five sequential phases of generative emergence: disequilibrium organizing; stress and experiments; amplification to a threshold; new order through recombination; and stabilizing feedbacks. These phases are described briefly in the chapter, and at length in Chapters 10 through 14. But to put those in context, I first introduce the notion of dynamic states and emergence outcomes.

Chapter 8. Introducing Dynamic States

The analysis in chapter 7 provides a valuable map of the process; however, it leaves out the experimental conditions that lead to dissipative structures. A close examination of these conditions in thermodynamics shows that they are vastly different from the conditions that social entities face in their efforts toward new order emergence. Chapter 8 describes these differences in some detail, leading to a generalizable model of organizing in social entities, called a "dynamic state" (Levie & Lichtenstein, 2010; Lichtenstein, 2011b). My claim is that the outcome of generative emergence is a dynamic state, which is operationalized in terms of four components:

Its *substrate*—a social ecology that includes people, culture, technology, markets, sectors, and social networks

Opportunity tension—the driver of generative emergence, which is a compelling opportunity and the motivation to pursue it

An *organizing model*—the core activities and method for creating value

Value creation—the goal of the entity, expressed through its products, services, and activities. In economic terms, this value is exchanged for money, which (re)generates the opportunity tension and the business model, thus creating a generative loop, that is, generative emergence.

In sum, the dynamic states model presents all aspects needed to understand generative emergence, distinguishing this prototype from the dissipative structures prototype of Exo-organization.[21]

Chapter 9. Outcomes of Generative Emergence

Building on the work of other complexity researchers, I have identified four possible outcomes to an emergence process. The most likely outcome, although one rarely mentioned by emergence scholars, is a *lack* of emergence, due to the dissolution of the system. In the world of entrepreneurship, this occurs all the time as unsuccessful attempts to launch, leading to the disbanding of the project.

Achieving success in an organizing process can result in three increasingly strong degrees of emergence. *First-degree order emergence* refers to a pattern or structure within a system that arises and remains stable over time. Most computational emergence results in first-degree order, as in NK landscape models, or “gliders” in the Game of Life simulation (Bar Yam, 2004). Although such order creation is intriguing, it does not confer much additional capacity to the system.

Second-degree systemic emergence occurs in the creation of a coherent system that displays qualitative novelty and nonreducibility, but does not include downward causation. Examples include the innovation of new processes in companies and the creation (enactment) of new business opportunities. In both cases a system emerges but without the power to affect its components.

The strongest form of order creation is *third-degree radical emergence,* the only form that expresses all five qualities of strong emergence: qualitative novelty, nonreducibility, mutual causality, structioning, and higher capacity. The result is an autonomous, self-generating social entity that creates value and is fully integrated into its social ecology. The prime example is the creation of new companies, which from their start-up have a causal impact on their employees. Likewise is the re-emergence of a venture, whereby the new organizing model and value proposition have a significant role in defining the future behaviors of the founders and employees.

In sum, the process of emergence can lead to no emergence, or to first-degree, second-degree, or third-degree emergence, with each subsequent degree reflecting greater systemwide impact and capacity created in the system. With this background, we can apply the insights from dissipative structures to real examples of organizational creation and re-creation.

Chapters 10–14. The Five-Phase Process Model of Generative Emergence

In the next five chapters, the five phases of generative emergence are carefully described; examples of each phase are drawn from my dissertation study of emergence in fast-growth companies. Although the cases have been summarized in previous papers (Lichtenstein, 2000a; 2000d; Lichtenstein & Brush, 2001), up until now the in-depth longitudinal data have remained unpublished.

Phase 1: Disequilibrium Organizing (Chapter 10)

All generative emergence begins when a lead agent (a founder) experiences an opportunity tension, by envisioning a business opportunity that he or she is highly motivated to pursue. That motivation pushes the founder into action, organizing people and resources toward enacting or realizing the opportunity through a viable business, project, initiative, or endeavor. The process pushes the system out of its norm and into "disequilibrium organizing." This chapter gives numerous examples of the opportunity tension that drove the entrepreneurs and companies in my study.

Phase 2: Stress and Experiments (Chapter 11)

As anyone who has organized something new can attest, the process is never easy; two qualities are sparked as a result. *Stress* occurs because the system is pushed into an arena of high pressure and great uncertainty. These stressors are felt as personal strain and sometimes interpersonal conflict, as participants struggle to deal with the intensity of the organizing effort. In addition, many ventures experience *fiscal stress* and financial challenges, primarily because the efforts are being invested into making the leap to a new state, rather than into the maintenance of previous revenue streams.

The parallel aspect of phase 2 is *experiments*—new ideas, spontaneous actions, and unique behaviors that are designed to deal with the intensity, reduce the stress, solve the challenges, and capture the opportunity. Although most experiments are not fully pursued, one of them will become the seed of new order—the basic frame around which a new system can emerge.

Phase 3: Amplification and Critical Events (Chapter 12)

Up to a certain threshold of activity, the results of stress and experiments will be dampened by the system, which seeks to retain its current structure as much as possible. Beyond the threshold, however, these "fluctuations" are amplified, leading the entire system to a *critical event.* This critical event is usually clear after the fact; retrospective sensemaking is used to explain the dramatic decisions that in some cases totally altered the system.

Phase 4: New Order Through Recombination (Chapter 13)

The result of this critical event is *new order*—something emerges, or the entire effort dissipates into failure. If successful, the emergent order accrues through a *recombination of elements* already in the system, along with the acquisition of new resources from across the social ecology. These shifts are usually rapid, expressing punctuated change.

Phase 5: Stabilizing Feedback (Chapter 14)

One of the insights from this research is the role that stabilizing feedback has in retaining the new order, whereas destabilizing feedback can push the system back into a critical mode. This stabilizing feedback occurs by strengthening new routines, developing formal ties with new stakeholders, or achieving certain goals. Such feedback processes are not described in dissipative structures theory; the fact that they can be seen in social situations offers an important example of how the transformative metaphor approach can double back to provide insight into the original science (Garud & Nayyar, 1994).

Chapter 15. Cycles of Emergence

My proposal is that these five phases are sequential, that is, they follow a causal logic, a specific succession in which each phase occurs in close relation to the one before. Once the entire process has occurred, the system settles down into its new dynamic state. Once a dynamic state emerges it may remain in place (even if growing incrementally) for many years. At the same time, it can become the preparation for another round of the process again. Thus, the entire five-phase process is really a cycle, what I call a "cycle of emergence."

This chapter presents four case studies that exemplify cycles of emergence: the initial emergence of Starbucks, Inc. (Lichtenstein & Jones, 2004); the emergence of the SEMATECH collaboration (based on the analysis in Browning, Beyer, and Shetler 1995); the emergence of HealthUSA (Lichtenstein, Dooley & Lumpkin, 2006) and the creation of The Republic of Tea (Lichtenstein & Kurjanowicz, 2010).

The cyclical nature of emergence provides a much more dynamic view of organizations (as Tsoukas & Chia, 2002, and Leifer, 1989, suggested). Further, this frame is easily extended toward a new theory of organizational development in which companies grow through a series of dynamic states rather than through stages in a life cycle (Levie & Lichtenstein, 2010). These implications are explored in Chapter 16.

Chapter 16. Cycles of Re-Emergence

The final step is to introduce the idea of re-emergence—the re-creation of an organization into a completely new dynamic state. In a simple way, re-emergence specifies the continuing cycles of emergence within an organization: first emergence, then re-emergence, then re-emergence again, and so on.

Within this description it is important to note again the difference between a cycle of re-emergence and the process of organizational transformation. As mentioned earlier, transformation events are triggered by crisis, which leads to reactive behaviors that try to solve the problem. In contrast, emergence events are initiated by an aspiration to create or expand a company's potential; this leads to creative proactive actions that draw on internal resources and values. Just as proactive creativity is more likely to spur innovation and more effective results (Heinzen, 1994; Axtell et al., 2000; Unsworth, 2001), so too similar positive effects are found for proactive entrepreneurial logic (Newey & Zahra, 2009), self-directed entrepreneurial behaviors (Baron, 1998; Baron & Markman, 2003), and proactive thinking by entrepreneurs (Yusuf, 2012).

Chapter 17. Boundaries of Emergence, and Beyond the Boundaries

The final two chapters offer a broader context for the work. Chapter 17 focuses on *boundaries,* in two specific ways. First, boundaries refer to the physical limitations of the container that holds a process. In the dissipative structures experiment the boundaries are the walls of the cylindrical vessel that holds the fluid and chemicals. It turns out that the dimensions of the boundary—literally the size of the experimental container—have an important influence on the outcome of the experiment (Swenson, 1997; Goldstein, 2011). In a similar way, the constraints of a creative situation play a constructive role in any emergence process. As Juarrero (1999, p. 133) suggests, "constraints can simultaneously open up as well as close off options." In this meaning, boundaries are "constructive constraints" that actually enable order to emerge. Thus, attending to the boundaries of an emergence process should have positive implications for our understanding and enactment of emergence.

Second, boundaries refers to the theoretical "boundary conditions" of the model I have presented (Whetten, 1989). These boundaries allow me to specify which phenomenon should be explainable by the five-phase process model, and which one is not. In brief, I will claim that the sequence of five phases is applicable to organizations as the unit of analysis. That is, I would expect the cycle of emergence or re-emergence to be valid for emergence *in* organizations or for the emergence *of* organizations.

This claim reveals two distinct dimensions that describe different contexts of emergence. The first dimension distinguishes emergence within organizations from emergence of organizations. The second dimension distinguishes emergence from re-emergence. Putting these together as a two-by-two typology suggests four avenues for continuing research in the field:

a. *Emergence of organizations* is best represented by the PSED research on new venture foundings (Gartner, Carter, & Reynolds, 2004; Gartner, Shaver, Carter, & Reynolds, 2004).

b. *Re-emergence of organizations* refers to entrepreneurial "re-invention" (Baker & Nelson, 2005; Mullins & Komisar, 2009), which may also reveal insights into the mutability of an company's identity (Gioia, Schultz, & Corley, 2000).

c. *Emergence within organizations* can explore the range of emergences in organizational settings, including emergence of systems, departments, products/platforms, and even governance systems, as has been done by O'Mahony and Ferraro (2007).

d. *Re-emergence within organizations* offers a unique lens to explore the re-creation of existing structures, systems, or routines. It can also draw forward strategy process research, which is gaining momentum in the academy.

Related to this discussion of boundaries, I explore empirical contexts of emergence that lie "beyond these boundary conditions." For example, research in psychology and cognitive development suggests that several elements of a cycle of emergence are expressed during major shifts in cognitive learning and leadership development (Boyatzis & Kolb, 2000; Boyatzis, 2008) or in aspects of creative flow experience (Csikszentmihalyi, 1990; 1996).

In addition, the five-phase process model can be applied to more macro contexts, to see if and how it is validated in arenas such as the emergence of alliances and collaborations (Browning et al., 1995), self-organizing supply chains (Choi, Dooley, & Rungtusanatham, 2001; Pathak, Day, Nair, Sawaya, & Kristal, 2007), and network emergence (Biggiero, 2001). Broader contexts are also ripe for exploration, including industry creation (Garud, Jain, & Kumaraswamy, 2002; Garud & Karnøe, 2003; Tan, 2007; Dew, Reed, Sarasvathy, & Wiltbank, 2011), the emergence of institutional clusters (Chiles & Meyer, 2001; Ehrenfeld, 2007), and the dynamics of institutional entrepreneurship (Maguire, Hardy, & Lawrence, 2004; Maguire & Hardy, 2009; Purdy & Gray, 2009).

Chapter 18. Enacting Emergence

Can emergence be intentionally pursued or enacted? This last chapter explores an "emergence praxis"—three ways to instigate generative emergence. The first is to create the conditions for emergence in organizations (Marion & Uhl-Bien, 2001; McKelvey, 2004a; Hazy, Goldstein, & Lichtenstein, 2007; Osborn & Hunt, 2007; Uhl-Bien et al., 2007; Uhl-Bien & Marion, 2008; Goldstein et al., 2010). For example we (Lichtenstein & Plowman, 2009) analyzed three studies on emergence to identify ten actions that leaders can pursue to initiate emergence. Examples include generating disequilibrium by embracing uncertainty, encouraging rich interactions through "relational space," supporting collective action, accepting tags, and integrating local constraints. Together these behaviors of "generative leadership" increase the likelihood that innovations can surface in social ecologies and companies, leading to emergence.

A second way to instigate generative emergence would be to enact each of the five phases of emergence in sequence, with the aim of purposively generating an emergent entity. In brief, the process starts by assessing the social ecology for collaborators, resources, and synergies that can aid in the goal. The next step is to generate opportunity tension, pursuing actions that create disequilibrium, while allowing for stress and producing experiments that may seed new order. If these continue momentum will build to a critical event, a trigger point of system change. New order is created encouraging a recombination of resources and elements, in an iterative process that increases the overall capacity of the system. Finally, if the new state is effective, the generative leader can apply stabilizing feedback, to retain the sustainability of the system. To be clear, this description is a proposal which will require a good deal of experimentation to test and clarify.

The book concludes by making a proposal for the emergence of social change. The idea is to combine generative emergence with Gunderson and Holling's (2001) work on ecosystem resilience. Their research shows that natural and social ecosystems evolve through four phases of an "adaptive cycle." It turns out that these phases are extremely similar to the phases of generative emergence: An initial state moves through the stages of exploitation and conservation; these can lead to a rigidity state. In some cases the system is triggered to release the built-up resources; these get re-organized and recombined into a new initial state. Linking the two models suggests a way to extend emergence to economic and natural ecosystems. In addition, the resilience framework emphasizes sustainability, which is itself a core value of generative emergence—both focus on building a healthy and viable world.

Overall, my hope is that this book provides a foundation for rigorous and relevant studies of generative emergence, and for conversations that lead to a discipline of emergence. In one measure the book culminates 34 years of my own thinking and research, and integrates over 100 years of study and more than 750 cited papers. At the same time it should be read as a work in progress, a first step in an ongoing journey toward understanding the dynamics of emergent order in our organizations and our society as a whole.

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Table 1.1.

"LEVELS" OF EMERGENCE IN THE SOCIAL SCIENCES

Reference	**Emergence of: (from Title)**	**Topic Area or Field**
Nowak, Tesser, Vallacher, &	Collective properties	Psychology; identity theory

Borkowski, 2000		
Marinova, Moon, & Kamdar, 2013	Leadership emergence	Leadership
Zaror & Guastello, 2000	Leadership emergence	Leadership
Arrow & Burns, 2004	Group norms	Groups; organizational behavior
Sawyer, 2001	Downward causation	Groups; organizational behavior
Lichtenstein, Dooley, & Lumpkin, 2006	Emergence events	Entrepreneurship
Lichtenstein & Kurjanowicz, 2010	New ventures	Entrepreneurship
Biggiero, 2001	Entrepreneurial networks	Entrepreneurship
Arikan, 2001	Entrepreneurial regions	Economic geography; networks
Chiles et al., 2004	Entrepreneurial regions	Entrepreneurship; regional development
Nonaka, 1988	Self-renewal in corporations	Innovation; organizational change
Plowman et al., 2007a	Organizational renewal	Organization transformation
MacIntosh & MacLean, 1999	Strategic renewal	Strategic change
Anand et al., 2007	New practice areas	Organization design
Sonenshein, 2009	Ethical issues	Organization theory; organizational change
Oliver & Montgomery, 2000	Knowledge firms	Organization theory, organizational design
Padgett & Powell, 2011	Markets and organization	Organization theory, networks
Tan, 2007	Phase transitions	Entrepreneurship; organizational theory
Browning et al., 1995	Alliance in semiconductor industry	Collaborations; networks
Purdy & Gray, 2009	Institutional fields	Institutional theory
Choi et al., 2001	Supply networks	Operations management
Kimberly, 1971	Stratification in complex systems	Sociology

Table 1.2.

FIELDS OF COMPLEXITY SCIENCE

Complexity Science	Originating Discipline
1. Determinist chaos theory	Mathematics; atmospheric science
2. Catastrophe theory	Mathematics
3. Fractals	Mathematics
4. Positive feedback: cybernetics, increasing returns	Information theory; systems theory; economics

5.	Self-organized criticality; power laws	Mathematics
6.	System dynamics	Information theory
7.	Complex adaptive systems	Computational science
8.	Cellular automata	Computational science
9.	Genetic algorithms	Computational science
10.	NK landscapes	Computational science
11.	Agent-based modeling	Computational science
12.	Autocatalysis, autopoiesis	Biology; systems theory
13.	Dissipative structures	Thermodynamics
14.	Ecosystem resilience	Biology; ecology
15.	Ascendency; evolutionary complexity	Ecology; evolutionary theory

Table 1.3.

NOTES

1. Research has identified these synergestic effects; see, e.g., Hainsworth (1986), Darley (1994), and Weimerskirch et al. (2001).

2. This work originated with the classic paper by Katz and Gartner (1988), which eventually led to the National Science Foundation (NSF)-funded Panel Study of Entrepreneurial Dynamics—the first randomized study of entrepreneurs in the world (see Gartner, Shaver, Carter, & Reynolds, 2004). This was followed quickly by parallel databases in Sweden. Studies showing the longitudinal process of organizational emergence are numerous; exemplars include Carter, Gartner, and Reynolds (1996); Delmar and Shane (2003, 2004), and Brush, Manolova, and Edelman (2008), who proved the accuracy of the original Katz and Gartner model. The first dynamic systems model of entrepreneurial emergence (Lichtenstein, Carter, Dooley, & Gartner, 2007) showed that for nascent ventures which successfully emerged, the *content* of organizing behaviors (e.g., doing

financial projections, doing marketing; finding funding, hiring first employee, and 24 others) was insignificant compared to the *process* of those behaviors, i.e., their temporal pattern over time.

3. Key work in this area has been done by Sarasvathy and Dew (2005) and Chiles and his colleagues (Chiles, Bluedorn, & Gupta, 2007; Chiles, Tuggle, McMullen, Bierman, & Greening, 2010). Tan (2007) showed that developing economies like China emerge in "phases" or cycles.

4. An influential simulation study by Krugman (1996) used a single-chained genetic algorithm model to show why populations of businesses tend to aggregate. This dynamic explanation was expanded in Chiles's dissertation work, which showed that the emergence of the Branson, MO, music theater cluster occurred in four "cycles" of self-organization (Chiles, Meyer, & Hench, 2004).

5. Smith & Gemmill, 1991; Smith & Comer, 1994; Guastello, 1995; Arrow, & Burns, 2004.

6. Innovation has been explored by many, including De Vany (1996), Brown and Eisenhardt (1998), and Van de Ven et al. (1999).

7. Mintzberg & Waters, 1982; Bettis & Prahalad, 1995; Garud & Van de Ven, 1992; Stacey, 1995; also, Sonenshein, 2009.

8. Overviews of the change/transformation aspects of emergence can be found in Weick and Quinn (1999), as well as in Bigelo (1982), Dooley (1997), Levinthal (1991), Lichtenstein (2000a), Tsoukas and Chia (2002), and Plowman et al. (2007b).

9. The emergence of new social institutions has been empirically explored in studies of institutional entrepreneurship. For example, Maguire, Hardy, and Lawrence

(2004) explained the dynamics of emergence for a new institutional field in medicine; Purdy and Gray (2009) showed the emergence of the new field of alternative dispute resolution; and O'Mahony and Ferraro (2007) studied the emergence of governance in open source software projects.

10. Although my expertise is more limited for the field of psychology, several examples make this point clear. Some studies in neurophysiology have shown the unpredictably emergence of neural "subfields"—see Poirier, Amin, and Aggleton (2008). Other examples are presented in Steven Strogatz's *Sync* (2000). One example of cognitive emergence is a recent study by McClelland and his students (McClelland et al., 2010) on connectionist and dynamical approaches to cognition. In terms of motivation, Guastello has been studying individual behavior using dynamic systems models for over two decades—these were summarized in his 2005 book, which shows how nonlinear dynamic models can improve the explained variance in certain longitudinal studies by over 400%, from r^2 of .15 to r^2 of .60 and more. See also parts of Strogatz's *Sync: How Order Emerges from Chaos in the Universe, Nature, and Daily Life.* Finally, for studies on the collective nature of individual behavior see Amabile, Conti, Coon, Lazenby, and Herron (1996) and Sawyer and DeZutter (2009).

11. For a summary of the emergence paradigm in sociology, see Sawyer's (2005) *Social Emergence: Societies as Complex Systems.* Padgett & Powell (2011) also provide a powerful re-analysis of socio-economic change using the complexity science of autogenesis. Some of the earliest applications of computational modeling were to

understanding patterns of collective social behavior, e.g. Schelling 1978, Epstein & Axtel, 1996, and Macy, 1991.

12. The search included EBSCO-Host's Academic Search Premier, EconLit, PsychArticles, SocIndex, ERIC, and Business Source Premier, on November 22, 2010. Title includes the word "emerge*" and (organization or group or management or industry or market or entrepreneur* or economic* or neuro* or cognit* or decision or individual or social or collective or behavior). Limiters = peer reviewed.

13. The five-phase process model has been shown to explain emergences in work groups (Goldstein, 1998, 1994; Smith, 1986); organizations (Leifer, 1989; Nonaka, 1988; MacIntosh & MacLean, 1999; Plowman et al., 2007b), start-up ventures (Lichtenstein, 2000d), alliances and collaborations (Browning, Beyer, & Shetler, 1995; Chiles, Meyer, & Hench, 2004), more.

14 Herbert Simon, 1955.

15. Except in reference to others' research.

16. Jeff Goldstein introduced me to the concept of a prototype of emergence; the following analysis owes a great deal to him.

17. Nonaka, 1988; Leifer, 1989; Goldstein, 1994; Smith & Comer, 1994; Bettis & Prahalad, 1995; MacIntosh & MacLean, 1999; Lichtenstein, 2000d; Plowman et al., 2007a.

18. Browning, Beyer, & Shelter, 1995; Buenstorf, 2000; Chiles, Meyer, & Hench, 2004; Tan, 2007; Foster, 2011; Padgett & Powell, 2011; Foster & Metcalfe, 2012.

19. Artigiani, 1987; Dyke, 1988; Lesourne, 1993; Juarrero, 1999; Gilstrap, 2007.

20. This was done by dozens or researchers. These applications started just a few years after Bérnard's initial work, in the research by Gibbs (1906) and Lotka (1922, 1945). Later, Schrodinger's classic book (1944) *What Is Life* inspired Odum and his collaborators (Odum & Pinkerton, 1955; Odum, 1988) to compute energy flows in ecosystems. Dissipative structures were applied to dynamic models of economics through efforts of Georgescu-Roegen (1971), as well as Odum and Odum (1976).

21. Note that a dynamic state is an exemplar of strong emergence, for it includes all five of the necessary qualities. Specifically, a dynamic state

(a) expresses qualitative novelty—in the unique output (product, service, offering) that includes but transcends its components, the people who make it up.

(b) is not reducible to its components—it cannot be explained as the simple combination of organizing behaviors, nor as the interactions across those behaviors (see Lichtenstein et al., 2007), and

(c) reveals mutual causality—because the emergent organization alters the behavior of its members, just as its members create and influence the development of the venture.

The emergence of a dynamic state involves

(d) **s**tructioning—an ongoing interdependence of agency and constraint. In particular, the founder (entrepreneur) identifies the ideal way to create value for a targeted market, in the most parsimonious way that she or he can. Organizing is thus a co-creative process of effectuation and bricolage.

Finally, if the dynamic state is to be sustained (sustainable), its emergence

(e) increases the capacity of the system in some way, either through efficiencies of scale, scope, or learning, or through new organizing models that save time and are more effective at producing real and reliable value to customers.