

## CHAPTER 2

### A NATURAL SCIENTIFIC FOUNDATION FOR PARTICIPATION AND EMPOWERMENT

#### *Implications of A Far-From-Equilibrium Thermodynamic Understanding of Health and Health Etiology*

"All our lives long, every day and every hour we are engaged in the process of accommodating our changed and unchanged selves to changed and unchanged surroundings; living, in fact, is nothing less than this process of accommodation..." (Samuel Butler, *The Way of All Flesh*, 1904)

#### INTRODUCTION

More than fifty years ago, under the determined leadership of Andrija Stampar (Seipp, 1998), the World Health Organization ratified the Preamble to its Constitution which asserts that "informed opinion and active cooperation on the part of the public are of the utmost importance in the improvement of the health of the people" (WHO, 1947). Since that time, the notion that people's participation is requisite to the attainment of health has received wide-acceptance as demonstrated by its inclusion in the Alma Ata Declaration (WHO/UNICEF, 1978), Ottawa Charter (WHO, 1986) and Jakarta Declaration (WHO, 1997) for Health Promotion.

Participation has most often been advocated on the grounds that it is requisite to both practical and ethical aspects of professional initiatives to enhance health. Practically, it has been argued, participation is necessary to secure both the success and sustainability of professional interventions within local communities (Green, Kreuter and Marshall, 1991), at larger populational levels (Labonté and Edwards, 1995), and in clinical contexts (Bergsma and Commers, 1997; Guadagnoli and Ward, 1998). Ethically, participation has been identified as a means of minimizing paternalism associated with professional health promoting activities. Arnstein (1969) provided an influential clarification of this point by asserting that participation minimizes paternalism to the extent that it is based on citizen control rather than citizen manipulation. Loewy (1989) has refined the point even more by arguing that the taking or receiving of such control is not only about increased individual and community autonomy, but implies correspondingly greater levels of responsibility at both levels as well.

However, though the practical and ethical foundations of participation are relatively well developed, far less attention has been given to the natural scientific foundation for the claim that participation can make an important contribution to health. In this chapter, therefore, I attempt to weave insights from thermodynamic theory and disparate aspects of research on salutogenesis to provide a plausible natural scientific foundation for the contention that participation is a critical tool for health promotion.

Further, I argue that helping people to have an "informed opinion" on health etiology implies a mandate for research into lay understandings of salutogenic health etiology and for communication between professionals and non-professionals on that basis. Helping people to "actively cooperate," in turn, suggests the relevance of empowerment for health. If participation is to be effective, people must not simply be aware of the factors which determine health. They must have sufficient jurisdiction over those determining factors as well as the ability to influence how those factors are conditioned by professionals.

## 1 A THERMODYNAMIC UNDERSTANDING OF HEALTH AND SALUTOGENESIS

In this section, I begin with a discussion of how life is understood within the theoretical framework of far-from-equilibrium thermodynamics and complexity theory. This discussion is used to distill a "complexity model" of health etiology which emphasizes the health etiological significance of two processes: energy dissipation within the human body as well as the body's exchange of energy with its environment. I then show how the complexity model reveals omissions in Antonovsky's (1979, 1987) empirical – if not theoretical – conceptualization of salutogenesis.

### *Defining a Fundamental Model of Health Etiology*

Thermodynamics is a branch of physics which deals with energy and its transformation. Energy and the exchange of energy comprise the basis of life. From the perspective of understanding living systems, the most critical insights from thermodynamics are embodied by the field's first and second laws, both of which arose out of the intensive study of combustion processes which took place in the 19<sup>th</sup> Century. In describing these laws, I paraphrase the more technical description of Toissant and Schneider (1998). The first law of thermodynamics states that energy can neither be created nor destroyed and that the total energy within a closed system will always remain constant. However, though the total quantity of energy within such a system may remain the same, the quality of that energy can change. The second law of thermodynamics relates to such changes in quality. If energy is transformed within a system, the second law says that the quality of the total energy involved will be lower after that transformation than before it began. The process by which energy is transformed from a higher to lower state of quality (or "orderliness") is known as entropy.

The end of the 20<sup>th</sup> Century brought a new understanding of entropy and its implications. Specifically, scientists in many disparate fields became concerned with the phenomena which occur in systems which have open exchange of energy with their environments (Prigogine and Stengers, 1984; Gleick, 1987; Waldrop, 1992). These systems, due to constant influxes of energy from – and losses of energy to – their surroundings are constantly challenged in their ability to maintain internal order, have been called "unstable" or "far-from-equilibrium." Applied to the universe as a whole, the second law of thermodynamics postulates that though the total quantity of existing energy may remain constant, its orderliness steadily and inexorably decreases with time. Yet the interesting thing about "far-from-equilibrium" systems is that they sometimes manage to maintain and even increase their internal order by building upon, rather than capitulating to, the constant challenges from their environments. Nobel Laureate Ilya Prigogine (1980; Prigogine and Stengers, 1984, 1997) has dedicated much of his career to the study of far-from-equilibrium systems which display *negentropic transformation*, or self-organization. He has employed the label "dissipative structures" to describe far-from-equilibrium systems which are successful at maintaining and enhancing their internal order at the expense of their environment.

The work of Prigogine and other early pioneers in far-from-equilibrium thermodynamics and self-organization provided a foundation for the rise of so-called "complexity theory." Since the mid-1980s, complexity theory has been dedicated to understanding theoretically how dissipative structures might originate and persist (Waldrop, 1992). In the complexity tradition, a dissipative structure is modeled as an "emergent system" defined by a set of internal relationships among constituent elements (i.e. a network). When the elements of such a system or the relationships among them are perturbed by outside energy, the system may be unaffected, altered, or even transformed. Bak and Chen (1991) demonstrated this in a fascinating experiment using a sandpile. One grain of sand was dropped every fifteen seconds onto a round mass scale, and the total mass of the pile was measured after each grain was dropped. Predictably, in the beginning many of the sand grains remained on the scale after being dropped and a pile formed. As the pile grew, however, so too did its slope become steeper and the resulting sensitivity of the pile as a whole to each grain dropped. When the pile reached a "critical state" (i.e. a steep enough slope), the influence of each grain of sand became highly unpredictable, causing avalanches (i.e. great mass loss) in some cases and little or no change in the pile's mass in other cases. The point that Bak and Chen's experiment makes so eloquently is that, depending on the history of a system, dramatically *different outcomes* can be the result of an *identical perturbation*.

This being the case, however, Kauffman (1991) has described how outcomes within a system are also a function of the types of perturbations to which a system is subjected. He has distinguished between two types of perturbations. The first type is called a minimal perturbation, which simply implies a sudden change in the status quo of a system. This would be the equivalent, for instance, of dropping a large stone onto the sandpile. The sandpile would probably display a large avalanche as a result of the impact of the stone;

assuming the stone fell off the mass scale, however, the pile would eventually return to its critical state and display the same behavior as before the minimal perturbation occurred. The second type is called a structural perturbation, which corresponds to a fundamental change in the relationships within a system (and thus of the system itself). One might induce a structural perturbation into the sandpile by vibrating the mass scale continuously or, alternatively, pouring glue onto the pile. Either of these actions would fundamentally alter the way the pile would be influenced by the falling grains. Perturbations, then, are the flip side of the systemic coin. Whether temporarily or permanently, they have the capacity to influence the internal workings of a system.

As Bak, Chen, Kauffman and their colleagues would agree, it is the intimate *interplay* between the initial conditions of a system and the nature of the perturbations to which the system is exposed which gives rise to processes of self-organization. Further, self-organization has come to be understood as the innate requisite force which underlies adaptation and evolution of systems. The question, then, is which initial conditions and what types of perturbations generally optimize the adaptive and evolutionary potential of a system. It has been suggested that systems may be most successful at adaptation when their initial conditions are "liquid" (i.e. quasi-stable). This means that a system must be far enough from equilibrium (i.e. vulnerable enough) to experience some change as a result of outside perturbations, but simultaneously have enough structure such that the system is not destroyed by those perturbations (see discussion of C. Langton in Waldrop, 1992). Correspondingly, outside perturbations need to be sufficient to challenge (perhaps significantly) but not to overwhelm the fundamental system structure. In short, in order to adapt most successfully, any system (and hence any dissipative structure) must find a balance between internal organization and instability as well as sources of appropriate energy exchange with the environment.

All dissipative structures are at least partially successful at achieving the two processes, and are therefore capable of maintaining and enhancing internal order at the expense of their environment. Nevertheless, even in this situation, the second law of thermodynamics requires that the quality of the total energy involved (i.e. the sum of the quality of the energy within and outside of the dissipative structure) must be degraded in the process. Building on earlier work, Toissant and Schneider (1998) show that the entropy relationships of dissipative structures can be described by the equation  $dS = dS_i + dS_e$ , where  $dS$  stands for the total entropy change in a dissipative structure,  $dS_i$  stands for the entropy produced within the dissipative structure, and  $dS_e$  stands for the entropy exchange between the dissipative structure and its environment. In order for the dissipative structure to maintain itself,  $dS$  must be less than or equal to zero (i.e. internal order must be maintained or enhanced). As we have seen, however, the second law requires that since energy is transformed, entropy must increase. This means that  $dS_i$  must be positive. Therefore, the equation shows elegantly that in order for a dissipative structure to maintain or enhance its own internal order, the total entropy produced within the dissipative structure must be less than that exported by the dissipative structure in its exchange with the environment (i.e.  $dS_e$  must be negative and  $dS_i < |dS_e|$ ).

Erwin Schrödinger (1944) asserted many years ago that life itself can be seen as a thermodynamic structure whose organization is maintained at the expense of its environment. Since then, this contention has become widely accepted among biophysicists, and the pathways by which energy at the molecular level stimulates cell organization (Waliszewski, Molski, and Konarski, 1998) and expression of the genotype (Kauffman, 1991) have become more clear. This implies, of course, that living systems are subject to the thermodynamic constraints described above, since these apply to all dissipative structures. We can thus reinterpret the points made in the previous paragraphs about the factors which promote the maintenance of dissipative structures (or emergent systems) as factors which are by definition relevant to living systems as well. In order for a living system to maintain itself:

- 1 the balance of internal organization and instability (i.e. system vulnerability) must result in an efficient processing of energy input so as to maximize the usefulness of a given level of entropy production within that living system (i.e. maximize the usefulness of  $dSi$ ).
- 2 sources of high-quality energy input and repositories for low-quality energy output in the environment must be sufficient to guarantee that the total entropy exchange between a living system and its environment ( $dSe$ ) comes at the expense of the environment rather than the living system itself.

When applied to living systems and especially to human beings, the word "health" has many connotations. In public policy, research, and clinical contexts, however, health is most often operationalized as longevity and the absence of measurable disease. We have seen that the ability of a living system to maintain itself, and thus to attain longevity, is dependent on the efficiency with which it produces entropy internally and its exchange of energy with its environment. Azzone (1996) has further argued that most diseased states can be seen as corresponding to an inhibition of an organism's ability to produce entropy in a way which promotes that organism's capacity for survival. Thus we can assert that the ability of a living system to maintain itself through the dissipation of energy drawn from its environment is a proxy for health.

This is in fact to say that far-from-equilibrium thermodynamics and the complexity theory which arose out of that tradition provide a fundamental model of health etiology. As points 1 and 2 above instruct, albeit at a general level, any factor which impacts the extent or manner of energy dissipation within a living system, or the exchange of energy between that living system and its environment, will also constitute a determinant of health status. Because these two main precepts represent a specific application of insights from far-from-equilibrium thermodynamics and complexity theory, I will henceforth refer to them as comprising a "complexity model" of health etiology.

### *Thermodynamics and Salutogenesis*

Antonovsky was well aware of both the understanding of life in the thermodynamic tradition and the ideas from complexity theory which had been used to clarify it. It is not



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