DISSIPATIVE STRUCTURE AND COMPLEX ENVIRONMENTS

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Prigogine and May have separately made contributions to the study of physical and biological organizations that have captured the imagination of those concerned with understanding social organization.

In this note I with to examine whether this interest is justified beyond the natural curiosity that something happening in distant fields might be of interest.

My starting point is the position I first outlined in 1962. Namely that:

"a comprehensive understanding of organizational behaviour requires some general knowledge of each member of the following set, where L indicates some potentially lawful connection, and the suffix 1 refers to the organization and the suffix 2 to the environment:

L_{11}, L_{12}
L_{21}, L_{22}

L_{11} here refers to process within the organization – the area of internal interdependencies: L_{12} and L_{21} to exchanges between the organization and its environment – the area of transactional interdependencies, from either direction; and L_{22} to processes through which parts of the environment become related to each other (i.e. its causal texture), the area of interdependencies that belong within the environment itself. (Emery, 1969).

The critical implication of this is that the *adaptiveness, and hence the viability, of an organization cannot be specified without some characterization of its environment* (its L_{22}).
There are apparent exceptions to this rule. If the environmental inflows to the organization (the L_{21}s) are random over the period of time that concerns us, regardless of organizational output (L_{12}s) then we can treat the organization as if only the L_{11}s matter. This state of affairs defines a *closed system*. Theoretically this is a special case of 'open system theory'. In practice it is probably the typical case in an

evolutionary system. That is, organizations evolve or move so that in their environmental habitats the random fluctuations of their L_{22} do not significantly effect their adaptiveness, and hence their viability. In social organizations statutory bodies and public utilities are a case in point – except that it is their legislative egg-shell that does the adapting; to provide insulation from the environment.

If the environmental inputs randomly fluctuate about a constant value, even a constantly but regularly changing value, regardless of organizational outputs, then we can treat the system as a "*Bertalanffy steady state system*". Evidence of adaptiveness would rest in the correlation of organizational outputs and the environmental inputs (Bertalanffy's transport equation).

In this second case the postulation of 'constant' implies some ordering in the environment, the L_{22}, that requires characterization. If that constancy is taken as a given then any extrapolation of the organization's future viability is a gamble on the future environment being an essentially unchanged continuation of the pat. In this case one can refuse to follow the rule enunciated above but only by restricting understanding of an organization to understanding what has brought it to where it is. Beyond that it is guesswork. Despite the logic of the matter, organizations that have a graph proving long-term unwavering success in some particular will regard this as proof of their capabilities (i.e. a product of the L_{11}) and disregard re-orderings taking place in the environment, $L_{22.}$

Prigogine's and Dissipative Structures.

Prigogine's claim to fame, and to his Nobel Prize, is that he has shown how order may arise out of disorder.

Boltzmann had already demonstrated mathematically that in non-zero temperature states some molecules will be kept by the others in a higher state of order. Prigogine and his colleagues identified degrees of ordering in complex chemical and physical systems that could not be explained by Boltzmann's Principle nor any other derivation from the Second Law of Thermodynamics. They identified some such cases with scientific rigor. They explain how these cases might arise from extreme random fluctuations in environmental inputs.

Two levels of ordering that depart from the closed system dynamics covered by the Second Law of Thermo-dynamics have been identified:

a. "non equilibrium stationary states" (steady state systems). Prigogine gives examples of crystals and demonstrates how they can still be described by Boltzmann's Ordering Principle i.e. by classical thermodynamic theory. He is not clear, however, about the conditions under which such states emerge.

b. a relatively higher level of ordering has been observed in complex chemical reaction-diffusion process. (This had already been well established by Rashevsky, 1940). Prigogine labels these as "dissipative structures". These structures are open to their environments in that they import, and export, energy *and* materials; instead of inexorably slipping back to the classical 'equilibrium' state of maximum entropy, as described in Boltzmann's law, they often 'dissipate entropy' and move to higher levels of order with associated gains in the 'free energy' (potential energy) available to move to yet higher orders; and these dissipative structures frequently have the ability to reproduce.

Prigogine achieved several things. First, he forced attention to physico-chemical phenomena that cannot be reduced to classical thermodynamics. Second, he devised his "non-linear thermodynamics" to show that the traditional language of thermodynamics could be stretched to describe these phenomena. The masters of this language could assume that they would be the masters of these newly recognized phenomena – the new open systems theorists. (That would indeed be worth a Nobel).

There is a hitch. Committed to an explanation that is but an extension of classical thermodynamics Prigogine is also committed to finding a principle which will explain how chaos can generate order. His finding is the principle of *order through (large) fluctuations*; up to a certain magnitude of fluctuations these systems behave as predicted by classical thermodynamics and then, at a critical point, there is a bifurcation and some of the systems take the path of 'dissipative structures'. This retains the mathematical language of thermodynamics, it retains Boltzmann's constant as a measure of relative order and it retains the root-metaphor for classical physics. It remains no more than a *description* of carefully observed events. At no point is Prigogine able to *explain* why these "above critical level" fluctuations occur, why some are critical whilst other much larger fluctuations in environmental parameters have no observable effects, not does he ever indicate the conditions where 'bifurcation' is probable.

This is an extension of the empire of physics that is without substance. The attraction of Prigogine's theoretical invention to people like the futurist Jantsch is that it appears to give absolution to the heretics who have had to think in open system terms about biological and social systems – provided, of course, that they now think in the modern day equivalent of Latin e.g. Boltzmann constants, Lyapunov functions and Belousov-Zhabotinsky waves.

The matter does not rest here. Prigogine has not been satisfied with describing the border phenomena of physics and chemistry (what he has been apt to call 'chemical physics') in variants of the traditional language of thermodynamics. He has sought to characterize, in the same language, the behaviour of primitive living systems, populations and social institutions.

In these ‘raids beyond the border’ he has indulged in a logical slide that betrays the weakness of his base position. Right at the point of discussing the most elementary forms of living matter, Eigen’s work on the evolution of biological macromolecules, he postulates that the pre-existence of autocatalysts and crosscatalysts are an essential pre-condition for the emergence of living ‘dissipative structures’. That is, ‘large random fluctuations’ are no longer a sufficient condition. At this point he has, apparently unwittingly, deserted the classical root-metaphor of order as a temporary, deviant creation of chaos and postulated order as a prerequisite for the emergence of greater order. At this point he also runs short of mathematical theorems and evidence from ‘non-linear thermodynamics’.

Prigogine has obviously brought comfort to his fellow physicists but he has yet to produce anything that would help us to explain the behaviour of open systems. His greatest achievement, yet to come, is that he may force the physicists to pay more attention to what one of Einstein’s pupils has been saying – disorder is to be understood as a function of different levels of order (Bohm, 197).

It is a conceit for Prigogine to write as is he were contributing to our knowledge of self-organizing systems’.

The only measure of order that Prigogine knows of, as a professional scientist is deviation from maximum entropy for a given temperature level. (Boltzmann’s law). This measure can, by its very nature, not give us the slightest aid in identifying the emergent levels created by ‘dissipative structures’. It tells us only whether or not they are back-sliding.

I have stated earlier that there is no possible way that biological evolution could have emerged from a Type I environment. By introducing his catalysts Prigogine has re-affirmed the point.

May

In association with the systems theorist Ashby, May has sought to demonstrate that some of the unusual behaviours of animal populations (in fact, populations of any living species) are a relatively simple function of increasing *complexity*.

Drawing on the same root-metaphor as Prigogine he has also sought to provide the model for behaviour of living systems.

His argument is that as any system grows to include more parts and/or the parts become more interdependent then that system *must* become less stable. His assumption is that the parts retain their own characteristics, they are randomly selected and they randomly relate as members of the system. If one further assumption is made, namely that there is only an even number of competing species e.g. 2,4,6,8,…, then computer simulations of this mathematical model reveal points at which gross instabilities occur.

We are faced with gross discontinuities in significant parts of our social life e.g. birth rates and GNP. Why should May's mathematical modeling be so attractive to social scientists? The answer would have to be that it provides a description of how discontinuities could be explained without stretching too far the traditional language of physics. When it is a matter of fact that elements act as parts of systems only by reason of some of their characteristics, that the selection of elements to become parts is far from random and that, as parts, their interrelationship is pre-determined by the pre-existing population of elements serving as parts, *then* the sacrifice of reality involved in accepting May's model is not justified just for the benefit of rigorous mathematical language. Even May's interesting computer results showing a relation between complexity and stability cannot safely be used as analogy. Complexity defined in his way as sheer numbers of different elements has little to do with the orders, levels and hierarchical arrangements that often enable the more complex ecologies to be the more stable and the simpler ones, as in mono-crop agriculture, to be most unstable.

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