

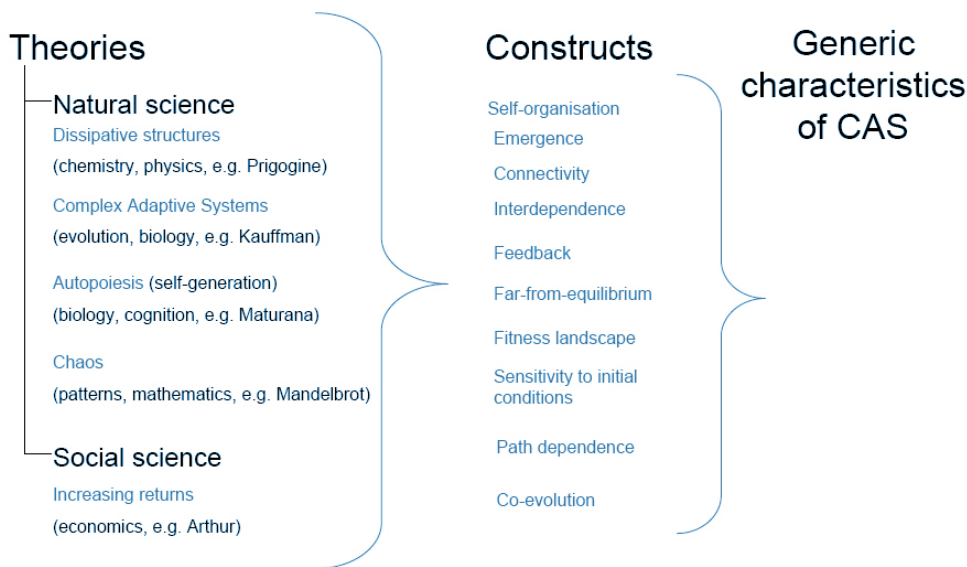


**Context of Research and Development**  
*Systems and Complexity Science*



**Cyberia Group**

# Systems and Complexity Science



*The four principles grouped together in Fig. 1, i.e. emergence, connectivity, interdependence, and feedback, are familiar from systems theory.*

Complexity builds on and enriches systems theory by articulating additional characteristics of complex systems and emphasizes their interrelationship and interdependence (we cannot isolate one principle/characteristic such as self-organisation and concentrate on it in exclusion of the others). The C-institute argues for a deeper understanding of complex systems by looking at several characteristics and by building a rich inter-related picture of a complex social systems. It is this deeper insight that will allow strategists to develop better strategies and organizational designers to facilitate the creation of organisational forms that will be sustainable in an ever-evolving environment.

Our approach is based on generic principles, since the principles are common to all natural complex systems. One way of looking at complex human systems is to examine the generic characteristics of natural complex systems and to consider whether they are relevant or appropriate to social systems.

The proviso, however is to understand that such a study is merely a starting point and not a mapping (i.e., social systems need to be studied in their own right - thus C-institute's action-based research approach).

## **The limitation is emphasised for two reasons:**

1. although it is desirable that explanation in one domain is consistent with explanation in another and that these explanations honour the Principle of Consistency (Hodgson 2001, p90), characteristics and behaviour cannot be mapped directly from one domain to another, without a rigorous process of testing for appropriateness and relevance (unit of analysis may be different, also, scientific and social domains have certain fundamental differences that may invalidate direct mapping - e.g. humans have capacity to reflect and make deliberate choice among alternative paths of actions, which is different from other biological, physical or chemical entities;



2. a number of researchers consider the principles of complexity only as metaphors or analogies when applied to human systems, however, such metaphors/analogies limit our understanding of the fundamental nature of a system under study. This does not imply that metaphor/analogy cannot be used. We use them as transitional objects all the time in the sense that they help the transition in our thinking when faced with new or difficult ideas or concepts. Since organisations are, by their very nature, complex evolving systems, they need to be considered as complex systems in their own right.

Another way of looking at complexity is suggested by Nicolis and Prigogine (1989, p8). It is less ambiguous, to speak of complex behavior rather than complex systems. The study of such behavior reveal certain common characteristics among different classes of systems and allow us to arrive at a proper understanding of complexity. This approach honours the Principle of Consistency and avoid the metaphor debate. It may however upset some sociologists who do not find arguments from science convincing. But this is to miss Nicolis and Prigogine's point, when they they emphasise the behaviour of all complex systems (they study the behaviour of complex systems in order to understand their deeper, essential nature). This provides us with the underlying reason for studying complexity. It explains and thus helps us to understand the nature of the world and the organisations we live in. The term complexity is used to refer to the theories of complexity (in the literature the plural theories is reduced to the singular for ease of reference) and complex behaviour, relates to the behaviour that emerges from the interplay of the characteristics/principles of complex systems.

Complexity is not a methodology or a set of tools (although it does provide both). It certainly is not a management fad. The theories of complexity provide a conceptual framework, a way of thinking, and a way of seeing the world using patterns, maps and territories.

## Connectivity and Interdependence:

Complex behaviour arises from the interrelationship, interaction, and inter-connectivity of elements within a system and between a system and its environment. Murray Gell-Mann (1995/96) traces the meaning to the root word, Plexus, meaning braided or entwined. Complex behaviour thus arise from the intricate inter-twining or interconnectivity of elements within a system and between a system and its environment. In a human system, connectivity and interdependence means that a decision or action by any individual (group, organisation, institution, or human system) may affect related individuals and systems.

This effect will not have equal or uniform impact, and will vary with the state of each related individual and system, at the time. The state of an individual or a system will include its history and its constitution, which in turn will include its organisation and structure. Connectivity applies to the inter-relatedness of individuals within a system, as well as to the relatedness between human social systems, which include systems of artifacts such as information technology (IT) systems and intellectual systems of ideas. Complexity theory, however, does not argue for ever-increasing interconnectivity, for high connectivity implies a high degree of interdependence. This means that the greater the interdependence between related systems or entities the wider the ripples of perturbation or disturbance of a move or action by any one entity on all the other related entities. Such high degree of dependence may not always have beneficial effects throughout the ecosystem. When one entity tries to improve its fitness or position, this may result in a worsening condition for others. Each improvement in one entity therefore may impose



associated costs on other entities, either within the same system or on other related systems. Connectivity and interdependence is one aspect of how complex behaviour arises. Another important and closely related aspect is that complex systems are multidimensional, and all the dimensions interact and influence each other. In a human context the social, cultural, technical, economic and global dimensions may impinge upon and influence each other (e.g., a case study, illustrates how what on the surface appeared to be a technical problem involving the integration of information systems across Europe, was partially resolved by paying attention to some social and cultural issues). A distinguishing characteristic of a CAS is that it is able to adapt and evolve, creating new order and coherence (a key defining features of complexity). Individuals acting at random or with their own agendas nevertheless can work effectively as a group or an entire organisation and may create coherence in the absence of any grand design. They can also create new ways of working, new structures, and different relationships, where hierarchies may be reversed or ignored.

## Degrees of Connectivity:

Propagation of influence through an ecosystem depends on the degree of connectivity and interdependence. Biological ecosystems are not totally connected. Typically each species interacts with a subset of the total number of other species, hence the system has some extended web structure (Kauffman, 1993, p255).

In human social ecosystems the same is true. There are networks of relationships with different degrees of connectivity. Degree of connectivity means strength of coupling and the dependencies known as epistatic interactions, i.e. the extent to which the fitness contribution made by one individual depends on related individuals. In biological coevolutionary processes, the fitness of one organism or species depends upon the characteristics of the other organisms or species with which it interacts, while all simultaneously adapt and change (Kauffman, 1993, p33). In other words a single entity (allele, gene, organism or species) does not contribute to overall fitness independently of all other like entities.

The fitness contribution of an individual may depend on all the other individuals in that context. This is a contextual measure of dependency, of direct or indirect influence that each entity has on those it is coupled with. In a social context, each individual belongs to many groups and different contexts and his/her contribution in each context depends partly on the other individuals within that group and the way they relate to the individual in question. An example is when a new member joins a team. The contribution that individual will be allowed to make to that team may depend on the other members of the team and on the space they provide for such a contribution, as much as to the skills, knowledge, expertise, etc brought by the new member.

In human systems, connectivity between individuals or groups is not a constant or uniform relationship, but varies over time, and with the diversity, density, intensity, and quality of interactions between human agents. Connectivity may also be formal or informal, designed or un-designed, implicit with tacit connections or explicit. Furthermore, it is the degree of connectivity, which determines the network of relationships and the transfer of information and knowledge and is an essential element in feedback processes.



## Co-evolution:

Connectivity applies not only to elements within a system but also to related systems within an ecosystem. An ecosystem in biology means, each kind of organism has, as parts of its environment, other organisms of the same and of different kinds... adaptation by one kind of organism alters both the fitness and the fitness landscape of the other organisms (Kauffman, 1993, p242). The way each element influences and is in turn influenced by all other related elements in an ecosystem is part of the process of co- evolution which Kauffman describes as a process of coupled, deforming landscapes where the adaptive moves of each entity alter the landscapes of its neighbors (Kauffman & Macready, 1995).

Another way of describing co-evolution is that the evolution of one domain or entity is partially dependent on the evolution of other related domains or entities (Ehrlich & Raven 1964; Pianka 1994; Kauffman 1993 & 1995; McKelvey 1999a & b; Koza & Lewin 1998). The notion of co-evolution places the emphasis on the evolution of interactions and on reciprocal evolution (Futuyama, 1979). In human systems, co-evolution in the sense of the evolution of interactions places emphasis on the relationship between the co- evolving entities.

A point emphasised by Kauffman is that co-evolution takes place within an ecosystem, and cannot happen in isolation. In a human context a social ecosystem includes the social, cultural, technical, geographic and economic dimensions and co- evolution may affect both the form of institutions and the relationships and interactions between the co-evolving entities (term entity is used as a generic term which can apply to individuals, teams, organisations, industries, economies, etc.). A distinction may also be made between co-evolution with and adaptation to a changing environment. When the emphasis is placed on co-evolution with, it tends to change the perspective and the assumptions that underlie much traditional management and systems theories.

Although we make a conceptual distinction between a system and its environment, it is important to note that there is no dichotomy or hard boundary between the two, in the sense that a system is separate from and always adapts to a changing environment. The notion to be explored is rather that of a system closely linked with all other related systems within an ecosystem.

