A COMPARATIVE STUDY of BIOLOGICAL and SOCIAL SYSTEMS

by

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INTRODUCTION

'The beginning is half of the whole'. Starting with the statement of Pythagoras, this introduction is written to point out the aim of the thesis and to give some insight into the subsequent chapters.

The aim of this thesis is to study the concept 'order' in biological and social systems. 'Order' is a very broad and abstract concept. It covers a wide range, extending from the simplest orders in nature to the complex man-made orders which we ourselves are part. We speak of the order of growth of a living being, the order of evolution of a living species, the order of society, the order of cultural evolution, the order of market mechanism, spontaneous orders, made orders, the order of language which constitutes the meaning and communication etc. Thus the concept 'order' has various implications and covers a wide range of phenomena. Before I present the basic questions that I have selected to study in connection with the concept 'order', I want to define this concept and the two related concepts structure, system very briefly.

In a most general way 'order' can be defined as "a state of affairs in which a multiplicity of elements of various kinds are so related to each other that we may learn from our acquintance with some spatial or temporal part of the whole to form correct expectations concerning the rest, or at least expectations which have good chance of proving correct.[1]" The consideration of 'relatedness of multiple elements of 'order' leads to the concept 'structure'. 'Stuere' which is the latin root of structure means to build, to grow, to evolve. This word is now treated as a noun but the latin suffix 'ura' originally meant 'the action of doing something'[2]. Structure which is derived from the verb'structate'actually means to create and dissolve. The Greek root of the word organize is 'ergon' which is based on a verb meaning to work'. "So one may think structure as 'working together' in a coherent way".[3] Evidently, molecules work together to make cells, cells work together to make organs, organs to make the individual living being, individual beings to make a society.

Another concept related to the concept of order is 'system'[4]. A 'system' should be conceptualized as an entity rather than a sum of parts.It is a whole, parts are coacting and interdependent, 'working together'. More precisely as Stafford Beer has put it "the arrangement and the rule whereby the parts are related in a whole is more important to understanding than the entire list of parts or the apperception of the wholeness of the whole"[5].

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(1) Frederick Hayek, Law, Legislation and Liberty (Chicago: The University of Chicago Press, 1973), p. 36.
(2) David Bohm, Wholeness and the Implicate Order (London: Ark Paperback, 1983) p. 116.
(3) Ibid.
(4) The concepts of 'structure' and 'system' are of course related to one another. An abstract discussion of their meanings is beyond the scope of this paper.
(5) Stafford Beer, Platform For Change (London: Johy Wiley and Sons, 1975), p. 28.

The basic question that this thesis attempts to answer is whether we can describe order in social systems or organizations in the same way as we describe it in biological systems or organisms. I hope to throw some light on the conceptualization of social systems by comparing them with biological ones. This comparison implies the discussion of the following questions: What are the factors which constitute the dynamics of biological and social systems? How can the environment of a social or biological order be described? Do such orders have a purpose? What are their unintended consequences and artifacts? What is the dilemma of maintenance versus change? If we consider evolution as an ordering process, can we compare the evolution of organisms with that of societies? Should the evolutionary processes be conceptualized as complexification, diffentiation or integration?

These questions can only be answered in an interdisciplinary framework. The first chapter of the thesis presents, General Systems Theory (GST), Cybernetics and the Second Law of Thermodynamics.

General Systems Theory (GST) delineates the importance of 'systemness'. The basic role of GST is to draw analogies or to use isomorphisms and models in science. It is an interdisciplinary doctrine which elaborates principles and models that apply to systems in general, irrespective of their particular kind, elements and forces involved. GST "is the scientific exploration of the 'wholes' and 'wholeness', hierarchic structure, stability, teleology, differentiation approach to, and maintenance of steady states, goal directedness etc.[6]. GST concerns the 'whole' rather than studies directed to isolating and disecting the parts into smaller units or narrower limits.

The second scientific area is cybernetics. The word cybernetics is derived from Greek word 'kubernētēs' meaning 'steersman'. At the same time the word 'governor' is derived from kubernētēs. Norbert Wiener, the father of cybernetics defines cybernetics as "the study of control and communication in animal and machine and its key explanatory mechanism is the feedback loop carrying a continual flow of information between the system, its parts and the environment"[7]. Feedback term means that the output is returning as input. According to Deutsh, "by feedback is meant a communications network which produces action in response to an input of information and includes the results of its own action in the new information by which it modifies its subsequent behavior"[8]. In negative feedback, signals from the goal are used to restrict outputs which would otherwise go beyond the goal. 'Negative' means simply the opposite direction from a detected deviation. Positive feed-

(6) Ludwig Von Bertalanffy, General Systems Theory (New York: George Braziller Co., 1978), p. 37.
(7) Walter Buckley (ed), Modern Systems Research for the Behavioral Scientist (Chicago: Aldine Publishing Company, 1968), p. xxiv.
(8) Ibid., pp. 387-389.

back is opposite of negative feedback in nature and effect. Instead of correcting or offsetting a deviation it adds to, augments it, pushing the system even further in the direction of initial direction. As it will be discussed in subsequent chapters Maruyama emphasizes 'deviation amplification' process, which has interesting implications.

Although negative feedback is a necessary condition for self-maintenance, steady-states or homeostatis, it is not 'good' in some normative sense. For example when developmental or creative change is desired rather than stability positive feedback is preferred.

The third scientific area relevant to the questions of this thesis is the Second Law of thermodynamics. Although the Second Law of Thermodynamics or entropy primarily reveals the problems of physics, it has recently been applied by social scientists to analyze order and disorder and their social implications.

First law of thermodynamics is 'conservation of energy', that is all matter and energy in universe is constant and it neither can be created nor destroyed. Only its form can change but never the essence. According to the second law of thermodynamics "matter and energy can only be changed in one direction, that is from usable to unusable or from available to unavailable or from ordered to disordered".(9)

(9)Jeremy Rifkin, <u>Entropy</u> (New York: Bantam Books, 1980), pp. 33-45.

The second law of thermodyamics can also be stated as the principle of 'increase of entropy'. There is a state function, a function of degree of randomness or disorder of a system. In an irrevocable process the entropy of the universe increases, in a reversible process the entropy of the universe remains constant. At no time does the the entropy of the universe decrease.[10].

Whenever an order is created anywhere on earth or in universe it is done at the expense of causing an even greater disorder in the surrounding environment.[11] Entropy concept can be summarized in a few words; in nature there is constant tendency for order to turn into disorder.

According to their thermodynamic properties, three types of systems are distinguished; isolated system, closed system and open system. Isolated system is defined as one that has no interaction with its environment, therefore there is no transfer of matter or energy between the isolated system and its environment. A closed system is the one that cannot transfer matter to or from its environment, but is capable of transferring energy in the form of heat, work or radiation to and from its environment. Finally, an open system is the one that can transfer both matter and energy to and from its environment.[12] For example, the univer:

(10) John E. Hearst and James B. Ifft, Contemporary Chemistry, (San Francisco: W.H. Freeman Co., 1976), pp. 345-350.
(11) Rifkin, op. cit., p. 5.
(12) Hearst and Ifft, op. cit., p. 340.

is accepted as an open system and the earth with respect to universe is a closed system."Life" is an open system as well.

Matter and energy are two essential factors of open systems when they are concerned with their thermodynamic properties. Kenneth E. Boulding(13) adds 'know-how' as a third essential factor. He emphasizes that human organizations are living open systems and they could be analyzed accordingly. 'Things,' 'Organizations' and 'People'(14) are all human artifacts of our-man made environment, which we ourselves created.

Dynamics of open systems require both stabilizing, structure-maintaining process and immanent unstabilizing and structure changing process inherent in personality and society. In other words, crudely, there are two forces opposing each other, one is trying to maintain the existing structure and conditions intact, the other one is continously searching for novel states. The former force can be described as an ordering process where the latter as a disordering process. It is not easy to visualize the situation as the process is nonlinear. Complexification, differentiation, integration, evolution are the implications of the ordering process, although different names are used, the content remains the same.

The second chapter 'Biological Systems' emphasizes the dynamics of open systems, and distinguishes self-maintenance and evolution under the headings 'adaptive self-stabilization' as the former and 'adaptive self-organization' as the latter.(15)

Adaptive self-stabilization includes homeostatis and learning. Homeostatis in biological sense signifies the adaptation to environment by self-regulation controlled by genetic codes, handed down from generation to generation. In other words homeostatis maintains the existing organismic structure through a genetic programming of behavior. Learning maintains that structure by evolving behavior patterns based on individual experience. In addition to behavioral responses acting directly on the environment, some homeostatic responses compensate for changes in environmental states through a partial and temporal re-organization of the states of the organism. Further examples in the chapter may help to clarify the concepts.

Adaptive self-organization or evolution, on the other hand, refers to relatively long-term changes. In a biological sense genetic codes represent the norms of the organism, they are the internal constraints and they are fixed. Learning can effect a new temporal reorganization of the norms through new and flexible behavior patterns,

(15) Erwin Laszlo, Introduction to Systems Philosophy (New York: Gordon and Breach, 1972).

But as emphasized before, these reorganizations are not heritable. Again in biological sense, when the reorganization effects the 'very-structure' of the system that is genotype by means of mutations or other factors exposed to the test of natural selection, we can talk about evolution or adaptive self-organization.

The process of evolution is activated by positive feedback mechanisms which can also be interpreted as the change from the less to more complex states of organization. In fact, complexity, evolution, differentiation, integration are all complex abstract concepts. They are not easily defined. Prigogine stated that "whenever we look, we discover evolutionary processes leading to diversification and increasing complexity.[16]

In a way, animals are more complex organisms than plants. In another way, with their photosynthesizing apparatus, which animals lack, plants are more complex. The only sure thing about the direction of evolution is toward better adaptation to the environment insured by natural selection.[17]

Another interpretation of the concept 'complexity' put forward is by Rapoport and Howarth. They cited in their paper that complexity is exemplified in "a collection

(16) Illia Prigogine quoted in Hayek, op. cit., p. 158.
(17) Anatol Rapoport, Conflict in a Man-Made Environment (Middlesex: Pengiun Books, 1974), pp. 61-68.

interconnected by a complex net of relations can be distinguished as[18]

a) organized simplicity

b) chaotic complexity

Weaver, on the other hand analyze the concept as

a) organized complexity

b) unorganized complexity[19]

In either case according to Rapoport and Howarth or Weaver, organized simplicity or organized complexity is defined as the system in which the interrelated components can be understood . There exist no closed loops in the causal chain, simply the system is an additive or a serial complex of components. In Weaver's phrases it is "a sizeable number of factors which are interrelated into a organic whole."[20]

At the other extreme is chaotic complexity or unorganized complexity, where the number of entities is so vast that interactions are explicable by laws of change, probability, and the second law of thermodynamics. As mentioned before, principle of increase of entropy is based on the statistical tendency of the matter and energy to prevail ove disorder. The image of chaotic complexity is not determin-

(18) Buckley, op. cit,, pp. 71-73.
(19) Von Bertalaffy., op. cit., pp. 34-35.
(20) Ibid.

istic in the way in which a system of differential or difference equations is deterministic, but is probabilistic and interactions can be described in terms of continuosly distributed quantities and gradients. According to Roegen one of the most important properties is that "statistical thermodynamics completely denies the possibility of any purposive activity"[21] because purposive activity is determined by the law of mechanics.

The third chapter views 'society as a complex adaptive system'. And throughout the context social system and organization are used synonymously. Thus, organization can be defined as the production of joint effect by two or more persons, it is produced by the interaction of two or more human beings.

Organizations are distinguished as formal and informal. Formal can be described if the actions of two or more parties are consciously coordinated toward a joint effect. Organization is informal if the "joint effect is produced without conscious coordination as when the separate and self-oriented actions of several neighbours maintain their own properties create the joint effect of an attractive neighborhood that enhances the property values of all."[22]

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(21) Nicholas Georgescu-Roegen, Entropy and the Economic Process, (Massachusetts: Harvard University Press, 1974), p.194
(22) Alfred Kuhn, Logic of the Organization (San Francisco: Jossey and Bass Publishers, 1972), p. 17.

Hayek also describes formal organizations under the headings of 'made order' or 'taxis', and informal organizations as 'spontaneous orders' or 'cosmos'.

Formal organizations or made orders are defined as deliberate arrangement to pursue our concrete goals. On the other hand informal organizations or spontaneous orders as Hayek put "will often consist of a system of abstract relations between the elements which are also defined only by abstract properties and for this reason will not be intuitively perceivable and not recognizable except on the basis of a theory accounting for their character"(23).

Informal organizations are also self-organizing and self-generating systems best exemplified in Hayek's phrase:

> "One of the most important of these self-generating orders is the wide ranging division of labour which implies the mutual adjustment of activities of people who do not know each other. This foundation of modern civilization was first understood by Adam Smith in terms of the operation of feedback mechanism by which he anticipated what we know as cybernetics".(24)

Leaving the further discussions to the third chapter, another point to be emphasized is the 'analogy' of organism and organization. Biological functions of the organism are

(23) Hayek, op. cit., p. 39.

(24) Ibid., p. 158.

demonstrable in organizations, they sometimes reproduce or metasize, they respond to stresses, they age and they die. They are also open systems, have their metabolism which transfer matter and energy and their physiology, which enables communication, integration, and control.

However, organisms are distinguished from organizations in several aspects. First, in an organism most of the individual elements occupy fixed places. At least once the organism is mature, they retain their places once and for all. Second, organisms are more or less constant systems consisting of a fixed number of elements, even if the elements are replac by equivalent ones, retain an order in space perceivable with senses. Third, consequently, organisms are more concrete than 'spontaneous orders' of society, which may be preserved although the total number of elements changes and the individual elements change their places. Hayek's approach is "the relatively concrete character of the order of organism shows itself in the fact that their existence as distinct wholes can be perceived intuitively by the senses, while the abstact spontaneous order of social structures usually can only be reconstructed by the mind"(25).

The important issue of cultural evolution is also included in the discussion of the third chapter. The eolution of institutions, organizations, customs, similarities

(25) Ibid., p. 52-54.

and dissimilarities are compared to biological evolution.

Evolution or adaptive self-organization defined by Darwin is "descent with modification"(26). The evolution of organisms depends upon heredity and hereditary modifications are the basic materials for evolution. Darwin proposed the 'natural selection' concept as the necessary tool to modify the genetic material. Natural selection represents the environmental pressure which the organisms have to face. 'Survival of the fittest' defines the most compotent individual who adapted to the environment. But Dobzhansky's approach, the details of which will be exposed in the third chapter, is very important in this context, 'natural selection does not act like a sieve'(27). As, internal constraints or genetic material are in constant relationship with 'external forcing' or environment. Adaptive self-organization results from either the modification of genetic material (mutations which are chance events) or migration to another environment. "Natural selection is an ordering factor, an antichance agent maintaining a meaningful and necessary correlation between the organism and their environment"(28).

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(26) Edward O. Dodson and Peter Dodson, Evolution (New York: D. Van Nostrand Company, 1976), p. 3.
(27) Francisco Jose Ayala and Theodosius Dobzhansky (ed). Studies in the Philosophy of Biology (Berkeley: University of California Press, 1974), p. 323.
(28) Ibid., p. 39.

On the other hand, when we speak of Social Darwinism, it is not very fruitful in the sense that it is concentrated on the selection of individuals rather than institutions and practices and on the selection of innate rather than culturally transmitted capacities of individuals.[29]

Man is considered independent from his physical environment, but he is captured by another kind of environment which is called the man-made environment or culture. Rapoport defines culture as "the result of the accumulation of collective intelligence through the accumulation of experience across generations"[30].

And Hayek puts "the structures formed by traditional human practices are the result of winnowing and sifting directed by differential advantages gained by groups from practices adopted for some unknown and perhaps purely accidental reasons"[31].

The most distinguished point of cultural evolution from biological evolution is the environment which we have created. In Peyton Rous's words " ..... what men believe determines what men do".[32] Adaptibility to the environment is not a guarantee for enhancing the survival potential of

(29) Hayek, op. cit., pp. 153-154.
(30) Rapoport, op. cit., p. 66.
(31) Hayek, op. cit., p. 155.
(32) Peyton Rous quoted in Ressler Potter <u>Bioethincs, Bridge to the Future</u> (New Jersey: Prentice-Hall Inc., 1971).

the culture. And not being so intelligent to be able to predict the unintended consequences, artifacts of 'orders', ultimate destiny of the human race is unknown, can not be predicted and no path can be said to be assured of success. All we can hope to do is to keep the pathway open ended and to permit several courses to be followed.

I. CONCEPTUAL FRAMEWORK

This chapter, which aims at exposing the framing concepts of the thesis is divided into four sections: Wholeness or systemness; General Systems Theory; Cybernetics; and Second Law of Thermodynamics.

Section 1 focuses on the problem of interpreting 'order' and argues for an emergent, wholistic view of the various levels of organization. Wholeness or systemness implied at each level of organization, moving from physical through biological, social and cultural levels, can be explained in terms of emergent properties. Emergent properties demonstrate that the properties of the whole are not only determined by the components, but by specific arrangement or interrelation of the components as well. In other words, continuity between systems is made possible by emergent properties.

Section two, General Systems Theory, tries to derive a unifying model which will seek explanation of 'order' and organization at different scientific areas.

Consequently section three, the physical law or the second law of thermodynamics seeks explanation of order, concerns with 'energy' and derives formulas of statistical and probabilistic in nature. The implications of the law are important for explaining the evolutionary process.

The last section, cybernetics, tries to model 'order' mainly emphasize on communication and control between the elements of the system. And suggests explanation on the self-regulation, and goal-orientation phenomenas.

1.1. Wholeness, Emergent Properties, Systemness

The concept 'order' intrigues the minds of philosophers and scientists from ancient Greeks to the present time. The attempts to interprete this phenomena leads to conflicting view points. And through out the history these views are described under different headings. Althouth they bear slight epistemological differences, these conflicting views can be summarized as, reductionism or fragmentation on one hand, and wholism, emergent properties, and systemness on the other.

Reductionism or fragmentation implies that 'order' can ultimately be understood by dissecting it into its smallest parts and units. Indeed, this approach, by separating parts from their environments and dividing and apportioning units have led to a wide range positive and constructive results. It has always been necessary for man, in his thinking to reduce his problems to managable proportions. Otherwise, we would not be able to deal with the whole reality at once. Creation of special subjects, division of labor can be viewed as the consequences. Even earlier "man's first realization that he was not identical with nature was also a crucial step, because it made possible a kind of autonomy in his thinking which allowed him to go beyond the immediately given limits of nature, first in him imagination and ultimately in his practical work"(1).

On the other hand, it is interesting that the word whole is derived from Anglo-Saxon origin meaning 'health', 'hale', that is, to be whole is to be healthy. Also, the English 'holy' is based on the same root as whole. All of these interpretations indicate that man has sensed always that the wholeness or integrity is an absolute to make life worth living.(2)

Wholism advances the contention that wholes or at least some wholes, are more than the sum of their parts, and implies that not all the properties of a living system are exhibited by its parts, because as soon as living system is dissected it loses many of its properties. Reductionism tries to explain the life in terms of chemistry and physics of its smallest component parts, at the molecular level.

Actually, the question "what are the causes of the world order" is latent within the interpretations of the natural phenomena and life. Aristotle distinguishes four

(1) David Bohm, Wholeness and the Implicate Order (London: Ark Paperbacks, 1983.) p. 2.
(2) Ibid., p. 3.

causes.[3]

(i) the matter or material cause of the thing

(ii) the law according to which it has grown or developed, the form, formal cause or formative cause.

(iii) the agent upon whose initial impulse the development began the 'starting point of the process' or as the later Aristotelians call it the efficient cause.

(iv) the completed result of the whole process, which is present in the case of human manufacture as a preconceived idea determining the makers whole method of handling his material, and in organic development in Nature as implied in and determining the successive stages or growth - the end or final cause.[4]

If any one of these had been different, the resultant state of things would also have been different.

Examples of biological process and artificial products of human skill will clarify the concepts. What was requisite in order that there should be now an oak and a statue on

(4) Taylor explains the Greek terms 'aitia', 'aition' which Aristotle uses to convey the notion of cause. Aition is an adjective used substantively, and means 'that on which the legal responsibility to a given state of affairs can be laid'. Similarly 'aitia'; the substantive, means the 'credit' for good or bad, the legal 'responsibility', for an act. The question what is responsible for the fact, that such and such a state of things now exists' arises. There are four partial answers which may be given, and each of these corresponds to one of the 'causes'.

(5) Taylor, Aristotle. (New York; Dover Publications, Inc., 1955) p. 50.

a given spot, if oak is considered as biological phenomena and the statue as the product of human skill.

The material cause of the oak, is a germ from which the oak has grown, and this germ must have had the latent tendencies towards development which are characteristic of oaks. And the material cause of the statue is the marble from which the sculptor plans to fashion his statue.

The formative cause of the oak lies within the genetic constituents and the definite law of growth. It must have had a tendency to grow in the way characteristic of oaks and to develop the structure of an oak. The formative cause of a statue is the general plan or idea of the statue as conceived by sculptor.

The efficient cause of the oak is the parent and its fresh acorn-bearing activity as the germ of the oak did not come from nowhere, it grew on a parent oak. The efficient cause of the statue includes the chisels and other instruments used by sculptor in his work.

The final cause is the stage which the germ is sapling is no longer becoming but is an adult oak bearing fresh acorns. And in sculpturing, it is the fully realized and completed statue.[5]

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(5) Ibid., p. 50-53.

Both in 'Nature' and in 'art' the 'formative' the 'efficient' and the 'final' tend to coincide in the same object. In nature only organic beings of the same kind give birth to other organic beings. This is the Aristotelian theory of causation. Although realized in different matter, the efficient cause produces a second being having the same 'form'. Thus the efficient cause (i.e. parent) is a 'form' realized in matter and the 'end' is the same 'form' realized in other matter. In 'products of art' the true source of the process is the 'form' the realization of which is the 'end' of final cause, only with this difference, that as efficient cause the 'form' exists not in the material but the way of idea or representation in the mind of craftsman(6). A sculpture does not produce another sculpture. The 'formative' cause is the 'idea' existing in the sculptors mind.

Two more remarks can be made in this connection:

(i) the notion of 'final' or 'end' of Aristotle's philoshophy has a teleological character. God and Nature, he tells us do nothing aimlessly but that does not mean that God and Nature act everywhere with conscious design. It is not a supernatutal and/or natural force governs the growth and development. The meaning is every natural process begins with 'form' and things develop by themselves towards their final stages or purposes which are

(6) Ibid.

fully realized in the matter. Imperfections in the matter are regarded as contrary to the normal course of Nature; exceptional hybrid reproduction is against nature and they are sterile.

(ii) Aristotle classified efficient causes under Nature, Intelligence (or Man) and Chance.

Nature as emphasized before, the form which is superinduced on the matter by the agent already exists in the agent itself as its form, the oak springs from the parent oak, the conversion of nutrient in to organic tissue is due to the agency of already existing organic tissue...

In the case of human intelligence or art, the 'form' is an representation, design, as have been emphasized before.

But a word can be added for Chance, causation by chance. This is confined to cases which are expections from the general course of Nature, remarkable coincidences. It is what we may call 'simulated purposiveness'. When something in human affairs happens in a way which subserves the achievement of a result but was not really brought about by any intention to secure the result, we speak of it as a remarkable coincidence.[7]

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(7) Ibid.

On the other hand Democritus tried to explain the world order by means of purely mechanistic hypothesis based on atomic structure and on the movement of atoms, which leads to a strictly materialistic and deterministic conception. This would not mean that the world is due to mere accidents, but every effect has behind its cause. Motion is an intrinsic property of the atoms, and the atoms of Démocritus are subject to mechanical law.[8] Although the fragmentary approach based on his atomic theory is supported, in essence, this theory leads us to look at the world as constituted of atoms, all working together. The ever-changing forms and characteristics of large-scale objects are now seen as the results of changing arrangements of the moving atoms. Evidently, this view was, in certain ways, an important mode of realization or wholeness.[9]

These seemingly conflicting view points can be incorporated into one unifying principle, '<u>emergent properties</u>'. The principle that at each level of increasing complexity of organization new properties emerge that are the result of the precise way in which the parts are arranged; in other words, 'the whole is greater than the sum of its parts'[10]

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(8) Ayala and Dobzhansky, (eds), op.cit., pp. 34-37.
(9) Bohm, op. cit., p. 8.
(10) David Kirk and Cecil Starr, <u>Biology Today</u> (New York: Random House, 1975), p. 814.

During the last 25 years particularly, the amazing discoveries that physicist and chemists have made concerning the structures and behavior of matter have profound implications for the biological sciences. Insights at the atomic and molecular levels have been applied rapidly to the study of cells, recombinant DNA research enable synthezing genes and proteins. From the stand point of pure reductionism the central dogma and the genetic code[(11)] might be predicted by breaking the DNA strand into its component parts of sugar, phosphate and bases and studying their properties. Here, one can understand the properties of each substance. On the other hand the pure holist would point out that when you break DNA into its component parts you lose the very properties you're attempting to understand.

One more example will serve to reinforce the principle of emergence at higher level of biological organizations. The fertilized egg of an animal normally develops into a well-integrated adult. But if the egg is centrifuged in the laboratory, lighter molecules and particles are forced to migrate to one end of the egg and the heavier molecules and particles are forced to migrate the opposite end. When this is done to the fertilized eggs of certain animals, the embryos develop abnormally. Most of the types of cells and tissues normally seen during development appear, but they appear in layers organized from the 'light'

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(11) See appendix A.

to 'heavy' end. Because the normal interrelationsships among parts have been disrupted, the embryo can not develop into a functioning adult. In this experiment the composition of the fertilized egg was not changed, but the organization changed considerably. As a result of different organization; entirely different properties emerged.(12)

Expressed in the principle of emergence the details of organizations of the parts play a key role in determining what properties the whole living systems will have. Certain properties of the parts are revealed only when they are organized in a particular way.

Prevailing theory now deals not only with the parts of systems but with the relationships among them. Individual organisms are themselves part of larger natural systems and the other that is characteristic of these systems also generates emergent properties. As in the other levels of organization, ordering gives rise to properties that not only favor the retention of order but actually create conditions favorable to the evolution of new patterns of order and thus to still newer properties. At each level of organization beginning with the elementary particles and moving through atoms, molecules, cells, tissues, organisms and even populations and ecosystems, new relationships are created and new properties emerge.

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(12) Kirk and Starr, op. cit., pp. 3-13.

The challange is three fold:

(i) to elucidate the properties of parts of living systems at all levels of organization,

(ii) to identify the organizational relationships that result in the emergence of new properties at each level,

(iii) to account for in physical and chemical terms, the precise pattern of organization occur. (for biological systems)(13)

We can now introduce the concept 'System' in Ackoff's words

> "In the last two decades we have witnessed the emergence of the 'system' as a key concept in scientific research. Systems, of course, have been studied for centuries, but something new has been added ..... The tendency to study systems as an entity rather than as a conglomeration of parts is consistent with the tendency in contemporary science no longer to isolate phenomena in narrowly confined contexts, but rather to open interactions for examination and examine larger and larger slices of nature. Under the banner of systems research (and its many synonymes) we have also witnessed a convergence of many more specialized contemporary scientific developments ..... (14)

Systemness covers a wide range from any two or more interacting or interrelated components such as ameoba in the sea to the eco-system where complex interactions take place. Aldous Huxley once proclaimed,

> "the world is, like a Neapolitan ice-cream cake where the levels-the physical, the biological, the social and the moral universe-represents the

(13) Ibid., p. 13
(14) Buckley (ed), op. cit., p. 11.

> cholate, strawberry and vanilla layers - we can not reduce strawberry to cholate - the most we can say is that possibly in the last resort, all is vanilla, all mind or spirit. The unifying principle is that we find organization at all levels ... Possibly the model of the world as a great organization can help to reinforce the sense of reverence for the living which we have almost lost in the sanguinary decades of human history".(15)

1.2. GENERAL SYSTEMS THEORY

Ludwig Von Bertalanffy writes that in early 1920's he "became puzzled about obvious lacunae in the research and theory in biology.... He advocaded an organismic conception in biology which emphasized consideration of the organism as a whole, a system, and sees the main objective of biological sciences in the discovery of the principles of organization at its various levels"(16). Later he elaborated this position to GST as a means to integrate all of the sciences, not just biology. GST in the narrower sense as Von Bertalanffy states "trying to derive from a general definition of 'system' as a complex of interacting components, concepts characteristic of organized wholes such as interaction, sum, mechanization, centralization, competition and to apply them to concrete phenomena'(17).

In 1953 Kenneth Boulding an economist in a letter

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(15) Aldous Huxley quoted in Haas and Drabek. <u>Complex Organizations: A Sociological Perspective</u> (New York: The Macmillan Company, 1973).
(16) Ludwig Von Bertalanffy. <u>General Systems Theory</u> (New York: George Braziller, 1968), p. 12.
(17) Ibid., p. 14.

to Von Bertalanffy cited,

> "I seem to come to much the same conclusion as you have reached, through approaching it from the direction of economics and the social sciences rather than from biology - that there is a body of what I have been calling 'general empirical theory or 'GST' in your excellent terminology, which is of wide applicability in many different disciplines".(18)

Boulding noted that although this was applicable in different disciplines, crossing disciplinary boundaries was most difficult.

In 1954, Von Bertalanffy, Anatol Rapoport, and Ralph Gerard established "Society for General Systems Research'.

In 1955 James G. Miller presented a report, in which he stated "Of the various possible integrations of the relevant data, we have found most profit in what we call 'general behavior systems theory'. After 10 years Miller outlined various components of this theoretical framework in a systemic way in his 'Living Systems,' 'Basic Concepts' published in 1965.

Walter Buckley summarized sociological and behavioral aspects of this framework in a diverse collection of readings in 1968, Modern Systems Research for the Behavioral Scientist.

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(18) Buckley, (ed), op. cit., p. 13.

Several impressive applications of the insights of GST to complex social organizations appeared almost simultaneously with Buckley's work. James D. Thompson published 'Organizations in Action' in 1967. Daniel Katz and Robert L. Kahn published 'The Social Psychology of Organizations' in 1966. And the first empirical study was done by Paul R. Lawrence and Jay W. Lorsch (Organizations and Environment)in which they applied GST to ten organizations that functioned in different types of environments. In 'The Bureaucratic Phenomenon' and 'the World of Office Worker' which is published in 1965, Crozier, has been effective in integrating descriptive and survey data with the process and negotiation themes. Finally, this thesis has adopted the 'conceptual set' of Alfred Kuhn. His work 'The Logic of Organizations' is published in 1983.

After the short history concerning the founders of GST, the aim and the methodology of GST needs to be explained.

Kenneth Boulding in his paper "GST The Skeleton of Scien defines the objective of GST as

> " to point out similarities in the theoretical constructions of different disciplines, where these exist and to develop theoretical models having applicability to at least two different fields of study, and hopes to develop something like a 'spectrum' of theories. A system of systems which may perform the function of a 'gestalt' in theoretical construction". "Such gestalts' in special fields have been of great value in directing research towards the gaps which

> they deal"(19). And "by developing a framework of general theory to enable one specialist to catch relevant communications from others"(20).

GST describes a level of theoretical modelbuilding which lies somewhere between the highly generalized constructions of pure mathematics and the specific theories of the specialized disciplines.

Major functions of these theoretical systems which are applicable to more than one of the traditional departments of knowledge are[21]

> "i. to investigate the isomorphy of concepts, laws, and models in various fields, and help in useful transfers from one field to another.
> ii. to encourage the development of adequate theoretical models in the fields which lack them.
> iii. to minimize the duplication of theoretical effect in different fields.
> iv. to promote the unity of science through improving communication among specialists. Thus science is split into innumerable disciplines continually generating new subdisciplines. In consequence the biologist, the physicist, the psychologist and the social scientist are, so to speak encapsulated in their private universes and it is difficult to get word from one cacoon to the other".

These functions are delineated at 1954 in the society for GST. There are two complementary approaches in order to construct 'gestalts' in GST. The first one is to look over the empirical universe and to pick out certain general phenomena which are found in many different

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(19) Ibid., p. 3.
(20) Ibid.
(21) Von Bertalanffy, op. cit., p. 15.

disciplines, and to seek to build up general theoretical models relevant the these phenomena. The second one is to arrange empirical fields in a hierarchy of complexity or organization of their basic 'individual' or unit of behavior, and to try to develop a level of abstraction appropriate to each.

Some equations of first approach will help to clarify the concept. For instance models of population change and interaction cut across a great many fields - ecological systems in biology, capital theory in economics which deals with populations of 'goods' social ecology and even certain problems of statistical mechanics. In all these fields population change, both in absolute numbers and in structure, can be discussed in terms of birth, and survival functions relating number of births and of death in specific age groups to various aspects of system. In all these fields the interaction of population can be discussed in terms of competitive, complementary, or parasitic relationships among populations of different species, whether the species consist of animals, commodities or molecules. Each of these individuals exhibits 'behavior' action or change, and this behavior is considered to be related in some way to the environment of the individual - i.e. - with other individuals with which it comes into contact or into some relationship. Each individual is thought of as consisting of a structure or complex of individuals of the order immediately below it, atoms are an arrangement of protons and electrons, molecules of atoms, cells of molecules plants, animals and men of cells, social organizations of men. The 'behaviour' or each individual is 'explained' by the structure and arrangement of the lower individuals or which it is composed, or by certain principles of equilibrium or homeostatis according to which certain 'states' of the individual are preferred. (Behaviour is described in terms of the restoration of these preferred states when they're disturbed by changes in the environment).

Another aspect of the theory of the individual and also of interrelationships among individuals which might be singled out for special treatment is theory of information and communication, which is founded by Shannon. At the biological level the information concept may serve to develop general notions of structuredness and abstract measures of organism which give us as it were, a third basic dimension beyond matter and energy. Communication and information processes are essential in the development of organization, both in the biological and the social world.

A second possible approach to GST is through the arrangement of theoretical system and constructs in a hierarchy of complexity, corresponding to the complexity of the 'individuals' or the various empirical fields. This approach is more systematic than the first, leading towards a 'system of systems'.(22)

In 1948 the founder of information theory, Warren Weaver, in his paper 'Science and Complexity' distinguished(23)

(i) problems of simplicity

(ii) problems of disorganized complexity

(iii) problems of organized complexity

He argued that science 'has succeded in solving a bewildering number of relatively easy problems whereas the hard problems and the ones which perhaps promise most for man's future lie ahead'. That is the theory of unorganized complexity which is ultimately rooted in the laws of chance and probability and in the second law of thermodynamics.(24)

On the other hand, problems of 'organized complexity' covers 'a sizeable number of factors which are inter-related into a organic whole'(25)

If the systematic approach, is overwieved the following are intended to serve as the objectives of GST(26)

1. Cybernetics - based upon the principle of feedback or circular causal trains providing mechanisms for goal

(22) Ackoff, "Towards a Behavioral Theory of Communication" Buckley (ed), op. cit., p. 209.
(23) Von Bertalanffy, op. cit., p. 34.
(24) Ibid.
(25) Ibid.
(26) Bertalanffy, "General Systems Review," Buckley (ed), op. cit., p. 11.

seeking and self-controlling behavior.

2. Information theory, introducing the concept of information as a quantity measurable by an expression isomorphic to negative entropy in physics and developing the principles of its transmission.
3. Game theory, analyzing in a mathematical framework, rational competition between two or more antagonists for maximum gain and minimum loss.
4. Decision theory - similarly analyzing rational chooses, within human organizations, based upon examination of a given situation and its possible outcomes.
5. Topology - or relational mathematics, including non-metrical fields such as network and graph theory.
6. Factor analysis - i.e. isolation by very of mathematic analysis, of factors in multivariable phenomena in phychology and other fields.

Among the models mentioned, the first two is applied throughout the thesis. The importance of cybernetics is in its application to open systems and revealing of the interpretations of many empirical phenomena by describing adaptive self-stabilization and adaptive self-organization. The second method used throughout the thesis is information theory for interpretation of the second law of thermodynamics and problems of complexity.

1.3. CYBERNETICS

According to the definition of its founder Norbert Wiener "Cybernetics is the science of communication and control in the animal and in the machine"(27). In 1948 Wiener proposed cybernetics as a new scientific method because,

> To live effectively is to live with adequate information. Thus, communication and control belong to the essense of man's inner life, even as they belong to his life in society".(28)

He described information as the content of what is exchanged with the outer world, as we adjust to it, and make our adjustments to it. And emphasized that "In control and communication we are always fighting nature's tendency to degrade the organized and to destroy the meaningful, as Gibbs has shown us, for entropy to increase"(29). Just as entropy is a measure of disorganization, the information carried by a set of messages is a measure of organization. Also Wiener was first to propose to interpret the information carried by a message as essentially the negative of its entropy and the negative logarithm of its probability(30).

The latent interpretation of 'control' is that whatever the system under control, there are general laws which

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(27)Norbert Wiener,"Cybernetics in History", Buckley (ed)., op. cit., p. 31.
(28) Ibid.
(29) Ibid.
(30) Ibid.

govern control processes. These laws apply to computers and servomechanisms, to the human nervous system, to populations of animals, to economy and to energy other large, complex probabilistic systems such as business firms and market economy. The adjective probabilistic is included in qualilifying the system since even well specified systems that are truly complex can in pratic be described only in this way.(31)

Alfred Kuhn stated that the problem of handling complexity have two stages

> i. "accumulating an adequate stock of appropriate simple models, so designed as to mesh with one another".
> ii. "assembling from that stock the proper subset of models that best describes the particular piece of reality under consideration".(32)

The basic of cybernetics to interprete complex organizational processes can be summarized in the 'conceptual set' proposed by Kuhn.

1.3.1. THE CONCEPTUAL SET

Detector, selector and effector or DSE are the basic system based ingredients which we analyze, seek to understand, and perhaps predict the behavior of a given goal-

(31) Stafford Beer, Platform for Change (London: Wiley and Sons, 1975), p. 105.
(32) Alfred Kuhn, The Logic of Organization (San Francisco: Jossey-Bass Publishers, 1982), p. 11.

oriented (purposeful) system. Because attention to DSE involves one system at a time, it constitutes an inter-system view. DSE is applicable to any system, whether the goal oriented system is an individual, a corporation, a fish or a robot.

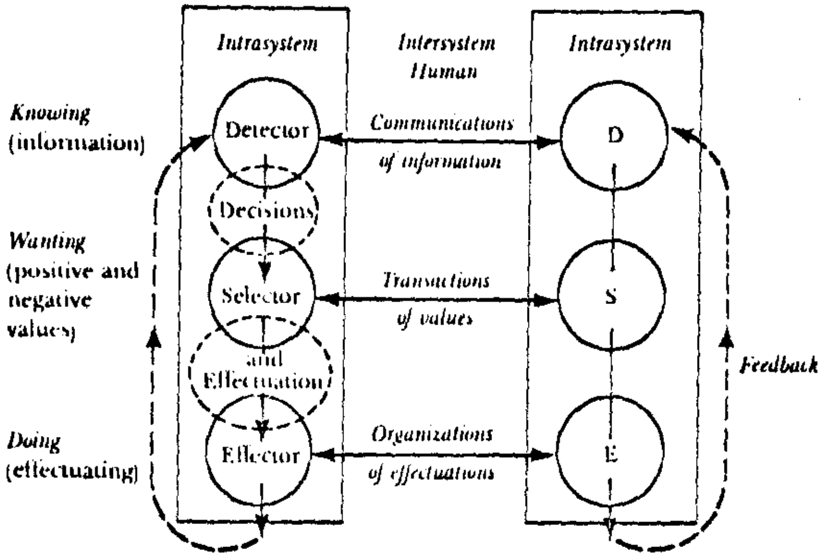
The second level deals with the intersystem analysis of interactions of two or more systems, and they are examined under the headings of communication, transaction and organization.

The rectangles are two-goal oriented systems, such as two individuals. The detector, selector and effector subsystems are shown inside each system, with communications, transactions and organizations connecting or relating their detectors, selectors and effectors respectively. The dashed ellipse labelled decisions intersects detector and selector, reflecting the fact that those two subsystems together actually choose, or select, behavior, while the effector carries it out.

Application of this model to social systems or organizations will be discussed in the forth chapter. (As noted before[33] social system and organization are synonymous throughout the thesis).

(33) See Introduction, p. 11.

Figure 1. The Intra- Intersystem Axis of Controlled Systems



		Intrasystem	*Intersystem*
Detector	(S) ↓	Information about *environment* (input)	*Communication:* An interaction analyzed with respect to its information content
Selector	(O) ↓	Preferences or values of the *system* (internal processing)	*Transaction:* An interaction analyzed with respect to its *value* content (humans only)
Effector	(R)	Actions or effectuations on environment (output)	*Organization:* An interaction analyzed with respect to its *joint effectuational* content

S → O → R = Stimulus → Organism → Response.

Opportunity function: A convenient term for the combined effect of the content of detector and effector—the perceived states of the environment and of one's capacity for action within it.

Preference function: A parallel term for the state of one's selector.

Decision: A selection of behavior on the basis of one's perceived opportunity and preference functions.

From Kuhn, 1974, p. 11.

1.3.2. CATEGORIES OF SYSTEMS

The first subdivision of types of systems is that between acting and pattern systems.

Acting systems - concrete systems whose parts interact, that is some kind of change is one component induces some kind of change in another component. Some matter, energy or both (matter-energy) must move from one component to another, that is the essence of interaction. The effect may be directly physical or communicational.

Pattern systems - are systems whose components are related in ways perceived, and possibly responded to, by and according to criteria of some acting systems but whose components do not interact. Real pattern systems are those in which different aspects of matter-energy are related. For example, the number of employees in a department is related to the amount of work to be done. Abstract or analytic pattern systems are those in which concepts or other abstractions are related. For example, a system of theory, or philosophy, the arrangement of shapes and colors. in a painting etc. In both real and abstract pattern systems the parts are related in somebody's mind, but they do not do anything to one another. The difference between the relationships in an organizations structure (pattern system) and the interactions of its people (acting system) will be discussed in the fourth chapter.

Acting systems can be either controlled or uncontrolled.

Controlled systems may also be called goal-oriented purposive, self-regulating or adaptive. They are not indifferent among alternative states or outcomes - they have a 'preference' among alternative states. Controlled systems are also distinguished by having a subsystem that performs an 'executive' function of selecting among possible alternative responses and of directing behaviors toward achieving or maintaining some preferred state of at least one variable. That subsystem is variously called the control mechanism, controlling mechanism, feedback mechanism, executive governor or decider. Any goals of the system are somehow contained in and made effective by this subsystem. By contrast uncontrolled systems have no goal(s), are not self-regulating and have no subsystem that constitutes a control mechanism, or feedback mechanism. The whole system simply resolves whatever forces act on it. The resulting outcome (or equilibrium) takes whatever form or level those forces produce. The system is indifferent among them - it has no 'preference'. As contrasted to the controlled system's 'preference' for a 'particular outcome', along with some ability to do, something about it, the uncontrolled systems 'accepts' equally any outcome that happens to occur.[34]

All living organisms are controlled systems. Man-made nonliving systems servomechanisms or cybernetic systems are controlled systems as well. Thermostat can be given as a classical example.And all nonliving natural systems are uncontrolled.

Organization has been defined as any system that consists of two or more interactions human beings. A super system that consists of two or more interacting organizations is also an organization. Organizations can range in size from two persons to the entire population of the earth.

<u>A formal organization</u> is one variety of controlled system and it exist whenever there is conscious coordination of the actions of two or more persons toward a particular result.[35]

<u>An informal organization</u> is an uncontrolled system they exist whenever there is some discernible joint result of human behaviors but the multiple efforts are not consciously coordinated toward that result[36]. As it will be detailed in chapter four Hayek calls it 'spontaneous

(34) Kuhn, op. cit., pp. 21-25.
(35) Ibid.
(36) Ibid.

order'.

Uncontrolled systems include the subcategory of ecological systems - uncontrolled systems of controlled subsystems, including biological and human ecology as well as market economic systems.

The 'controls' of a controlled system reside within the system, never outside it, and constitute its controlling, or guiding, mechanism. Forces outside the system that the limit or influence its behaviour are constraints whether they be imposed by nature or by persons or may be called environmental influences or simply environment[37].

1.3.3. SOME DISTINCTIONS

Matter-Energy Vs. Information (Pattern)

The behaviour or uncontrolled systems is a function of matter-energy considerations, while the behaviour of controlled system is a function of informational considerations. For example two leaves could be identical in weight, area, and chemical composition but have very different shapes. Their shape is irrelevant to such matter-energy consideration as oxygen or nitrogen cycle, biomass produc-

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(37) Kuhn, op. cit., pp. 26-37.

tion, or their use as compost. Their shape is crucial to the information question determining whether the leaf comes from an oak or a maple. The energy required to carry a telephone message is quite independent of whether communicators are speaking English or Turkish. System theorists have long distinguished matter-energy from information. Kuhn emphasizes that the word pattern had somewhat broader applications, and substitute 'pattern' for 'information'. The main difference between matter-energy and pattern is that the former is subject to the law of conservation and the latter is not. Unlike matter-energy, pattern can be created or destroyed, the total of matter-energy is fixed and finite but the total number of possible patterns is unlimited. Pattern can be amplified or reduced, transferred to where it is not without ceasing to be where it is, as with print made by type on the printed page or projection of a color slide onto a screen. Pattern can go through isomorphic transformations without ceasing to be the same pattern. A piece of music can take succesive forms of notes on a printed page, vibrations in musical instruments etc, yet the music remains essentially the same 'pattern' throughout the isomorphic transformations. A full grown human is 'the same pattern' as that of DNA in his or her genes. The whole subject of isomorphisism is relevant to pattern but not to matter-energy. Furthermore, two or more patterns can occupy the same space at the same time, such as ambigious drawings (two faces or a vase?). And finally, as Boulding states, "pattern is what evolves in biological evolution".(38)

For interactions of humans and of organizations the transmission of bits of information, signs, are very important. As the quantitative measurement of transmitted signs has disctinct interest within contemporary societies, particularly when computers are used, the question of what meaning a given communication conveys is a matter of symbolic, semantic, or sign-referent analysis and that is not quantifiable.

Patterns Vs Values

On the matter-energy side, at the level of many biological and physical systems, the quantities or intensities of matter-energy transfers are central to understanding interactions. There are also ways in which the quantities of wheat, coal, or automobiles exhanged by humans are important, if the behaviours of human beings are analyzed toward these exchanges, the focus is on the valuations people placed on the things exchanged.

The distinction between pattern and values is crucial to the organization theory and accompanying social science that follows, in that all analysis on interaction

(38) Ibid., pp. 33-37.

herein resolves around transfers of meanings via the movement patterns, to be called communications and around transfers of valued things, to be called transactions[39].

Operating Vs Control Subsystems

All goal-oriented or controlled systems have two distinct subsystems components. The one engages in the main operation(s) of the system and the other provides the instructions. For example in a guided missile they're the propulsion systems and the guidance system, for the heating systems they are the furnace and blower and the thermostat or the other etc.

Berrien made a distinction between maintenance inputs and signal inputs. i.e. - the one receives inputs or matter-energy and the other receives inputs of pattern or information, which can also be thought of a 'markers' in matter-energy. Following parallel usage, the first system within the human can be called maintenance or biological subsytems. For the operating systems, the outputs consist of matter-energy. For the control systems the outputs consists of instructions to the operating systems, instructions being a form of information.[40]

Inputs to the maintenance systems of human consists

(39) Ibid., pp. 34-36.
(40) Miller, op. cit., pp. 12, 63.

of food, liquids and air while output is heat, muscular actions, solid, liquid and gaseous wastes. The inputs to the control systems consist of sensory information, and the outputs consist of instructions to the muscles. Inputs to the operating system of formal organiaation consist of materials, fuel, supplies, and human effort; the outputs consists of its products and services. The inputs to its control system consist of information about the systems and environment and the outputs consist of instructions to various subsystem - though the complexities of formal organization, like those of the human organism, make it hard to draw sharp lines between control (decisional) and operating activities. In other words, the control system is the executive and the other is the operative.(41).

Controlled system, on the basis of information, maintains one or more variables within some specified range by returning the value of that variable to within that range if it happens to more beyond it, a controlled system used feedback to maintain a variable within certain range by the ingredients DSE. Thus DSE represents the environment, systems, and accomodating adjustment of system to environment. Again adaptive behavior will not be possible if any one of the three ingredient is left out.

Excluding living systems, uncontrolled systems are

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(41) Kuhn, op. cit., p. 38.

those that resolve the matter-energy forces acting on or in them. The operating systems of controlled systems also act by resolving matter-energy forces. By constrast a control system or a controlled system operates on the basis of information and the comparison of that information with some representation of (information about) a value. In uncontrolled systems Matter and Energy is the message, in controlled system it is only the medium.

According to some theorists, Norbert Wiener, Richard Taylor, Rosenblueth any end condition toward which a system reliably moves in constructed to be the 'goal' of the system. The present model and prepositions above which the resolution of Matter and Energy forces, no matter how reliable or predictable their end state, is never constructed in itself to represent a goal or control. Only if achievement of the end state is directed by instructions from an identifiable control system that operates on the basis of information can the system be constructed as controlled. In that case the goal is in the control system, not in the matter-energy portion, which is viewed as the operating system.

1.4. THE SECOND LAW OF THERMODYNAMICS

At first instance, the relavancy of laws of physics to the thesis might seem odd. But the second law of thermodynamics or law of increasing entropy is a statistical law, seeks explanation for the natural tendency of things to go over disorder. According to the second law, there is a state function, entropy, that is a function of degree of randomness, or disorder, of a system. In an irrevocable process the entropy of the universe increases. In a reversible process the entropy of the universe remains constant.At no time does the entropy of the universe decrease[42].

The classification of systems was presented in the introduction[43]. They were distinguished as 'closed' or 'open'. A closed system must, according to the second law of thermodynamics eventually attain a time-independent equilibrium state, with maximum entropy and minimum free energy, where the ratio between its phases remains constant.

On the other hand, open system may attain a time-independent state where the system remains constant as a whole and in its phases, though there is a continous flow of the component materials. (This is called homeostatis or steady state).

A closed system in equilibrium neither needs energy for its preservation nor can the energy be obtained from it. To perform work however, the system must be, not in

(42) John Hearst and James Ifft, Contemporary Chemistry (San Francisco:Freeman, 1976), pp. 345-349.
(43) See Introduction p. 6.
See Appendix B.

equilibrium but tending to attain it. To go on this way, the system must maintain steady state. The character of an open system is the necessary condition for the continuous working capacity of the organism[44].

The first and second laws of thermodynamics can be summarized as "the total energy content of the universe is constant and the total entropy is continually increasing"[45]. There are two states of energy, available, unbound or free energy states versus unavailable or bound energy states. An entropy increase, then, means a decrease in available energy. For instance "everytime something occurs in the natural world, some amount of energy ends up being unavailable for future work"[46]. Pollution is exactly the unavailable energy. Contrary to the popular belief that pollution is a by-product of production, actually pollution is the sum total of all the available energy in the world that has been transferred into unavailable energy. Waste, then, is dissipated energy. "Since according to the first law, energy can neither be created nor destroyed but only tranformed, and since according to the second law it can only be transformed one way toward a dissipated state- , pollution is just another name for entropy, that is, it represents a measure of the unavailable energy present in

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(44) Ludwig Von Bertalanffy, Emergy (ed),"The Theory of Open Systems in Physics and Biology",(New York: Penguin,1978), pp. 77-79.
(45) Isaac Asimov, <u>In the Game of Energy and Thermodynamics for Can't Even Break Even</u> (Smithsonian August 1970),p.9.
(46) Jeremy Rifkin, <u>Entropy</u>(New York:Bentam Books,1980),p.35.

the system".[47]

Pollution is a very good example for clarifying versatility of the concepts' order turning into disorder and available energy becoming unavailable.

Energy process, event, happening and everything that is going on in Nature means an increase of entropy in that part in that part of the world. Thus a living organism continuallly increases its entropy and tends to approach the dangerous state of maximum entropy which is death. The only way to stay alive is to feed upon 'negative entropy'. That is, a property of open systems, which can exchange both matter and energy, importing complex organic moledules using their energy and rendering back the simpler end products to the environment, thus the steady-state of the organism maintained.

L. Brilloin states that "the principles of thermodynamics, especially the second one apply only to dead and inert objects (closed and isolated systems). Life is an exception to the second principle. Living organism has special properties which enable it to resist destruction, to heal its wounds and to cure occasional sickness"[48].

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(47) Ibid.
(48) Brilloin, "Life, Thermodynamics and Cybernetics." Buckley (ed), op. cit., p. 38.

The applicability of the second law of thermodynamics to states of equilibrium or closed systems prove to be insufficient for explaining many problems of open systems such as electrochemistry, osmotic pressure, thermodiffision. Prigogine emphasized on these issues and developed the equation applicable for open systems(49). Accordingly the total change of entropy in open system can be written as follows:

$$dS = d_eS \quad d_iS$$

d_eS = the change of entropy by import

d_iS = the production of entropy due to irreversible processes in the system.

The term d_iS is always positive, according to the second law; d_eS can be positive or negative. Though the second law is not violated, or more precisely, though it holds for the system plus its environment it does not hold for the open system itself. That's how life feeds upon negative entropy.

According to Prigogine Von Bertalanffy conclusions:

a. Steady states in open system are not defined by maximum entropy, but by approach to minimum entropy production.
b. Entropy may decrease in such systems.
c. The steady-states with minimum entropy production are, in general stable. Therefore if one of the

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(49) Emery (ed), "Systems Thinking", op. cit., p. 78.

system variables are altered, the system manifest changes in the opposite direction.
d. The consideration of irreversible phenomena leads to the conception of thermodynamic; as opposed to astronomical time the first is non-metrical (i.e. not definable by length measurements) but arithmetical since it is based upon the entropy of chemical reactions and therefore, on the number of particles involved; it is statistical because based upon the second law; and it is local because it results from the processes at a certain point of space.

Again in Prigogine's words "Entropy may decrease in open system thus such system may spontaneously develop toward states of greater heterogeneity and complexity"(50).

The behavior of living organisms are quite peculiar. The evolution of species as well as the evolution of individuals, is an irreversible process. Eventually evolution has been progressing from the simplest to the most complex structures, although extinction of species occurs to some degree, the general trend contradicts the law of degradation presented by the second principle. Many other facts remain enigmatic; reproduction, maintenance of living individual and of the species, free will, etc.

(50) Ibid., p. 78-79.

..., the task of natural science (is) to show that the wonderful is not incomprehensible, but not destroy the wonder, for when we have explained the wonderful, unmasked the hidden pattern, a new wonder arises at how complexity was woven out of simplicity.

Herbert Simon

The Science of the Artificial

II. BIOLOGICAL SYSTEMS

In this chapter the concepts of systemness, order and cybernetics are applied to biological system.

The first section, systemness and order, refers to the nonseperability or interaction of constituents of the system without dissecting them to narrower limits. Order, in biological systems, on the other hand implies both spatial and temporal configuration and sequence of events.

The second section is constituted of three components. Biocybernetics I or adaptive self-stabilization refers both to homeostatis and learning, evidently, the point is to maintain the steady-state. It functions by coping environmental disturbances to the inner state of the organism. Adaptive self-stabilization processes are rather genetically programmed or learned. Learning maintains that structure by evolving behavior patterns based on individual experince. A special manifestation of homeostatis is growth which is included in this section.

The third section, surveyed under bio-cybernetics II or adaptive self-organization refers to evolution. The distinction from bio-cybernetics I is the change occuring in the 'very structure' of the organism, that is the genotype of the organism. Finally, the implications of the evolution and its connection with the second law of thermodynamics is studied.

2.1. Systemness and Order

The very essence of biological organization lies in the mutually constitutive interrelation of the organic components, that is the mere summation of their characteristics does not give a biological organism. As emphasized in the first chapter[1]. The relationships are so important that the most minute change in the interrelation of an identical number of components of an identical set or species may produce entirely different results.

Order refers to both spatial and temporal configuration and sequence of events. Spatial order denoted as the 'structure' or morphology of the organism, temporal order as its 'function' or physiology. In other words, structure implies function and function springs from structure. Laszlo stated that "order in structure and order in process are not different species of orders but different manifestations of the basic orderliness of the spatio-temporal pattern of the organism.[2]

Throughout the thesis, it is notoriously mentioned that, molecules work together to make up cells, cells make

(1) See section 1.1.
(2) Laszlo, op. cit., p. 71.

up tissues, tissues make up organs, organs make up organisms, individual beings, finally individuals make up a society ..... How does a zygote (fusion of egg and sperm) give rise to a complex individual instead of just a cluster of cells? The magic word is morphogenesis. Morphogenesis is the ordering process in biological organisms, it literally means the emergence of shape or form. It's better to note that the entire process morphogenesis is itself a subject of thesis and hitherto details of the whole process is not completely understood, it is given as example to illustrate the ordering process.

Morphogenesis can be defined as "the set of processes by which the characteristic micro and macro structures of living organisms grow and develop in space and time as a result of genetic programming"(3). Morphogenesis also implies differentiation and growth. Differentiation is a change leading to modification of structure or function. Growth is simply irreversible increase in mass. Consequently, many differentiating systems acting with remarkable coordination, mutual interaction and growth lead to morphogenesis.

Most body cells are asymmetical, ordered and spatially differentiated. From the shapes of cells body organs take their shape. Thus the process of intra-

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(3) Albert Lehninger, <u>Biochemistry</u> (New York: Worth Publishers Inc., 1975), p. 1011.

cellular differentiation is a key to morphogenesis. Understanding how cells become regionally specialized can provide insight into how a complex organism develops from a single cell.

As it is emphasized before, many processes of intracellular differentiation are not still understood. Some evidence exists that the properties of polypeptide chains determine three dimensional biologically active globular formations. That is, the three dimensional conformation of the native polypeptide chain is not imposed on it by external forces. It is the inevitable consequence of the tendency of surrounding water molecules to seek the state of maximum entropy and the tendency of polypeptide chain to seek its state of minimum free energy[4]. "Precision in the 'fit' of the various components with each other is provided by their structural complementarity"[5].

The phenomena of the 'ordering' process may be illustrated by the hydrophobic (non covalent or weak) interactions occuring in the stabilizing protein structure. There is a spontaneous tendency of randomly coiled polypeptide chains to fold into a highly ordered and biologically active conformation (with a significant

(4) Ibid., p. 1011
(5) Ibid.

decrease of entropy in the polypeptide chain. However, it is not a violation of the entropy law, which states that all processes proceed in the direction which maximizes entropy or randomness. The phenomena can be explained in terms of 'balance of forces'. That is, the polypeptide chain seeks its own conformation of maximum randomness or entropy. The essential factor is the presence of nonpolar R groups (hydrophobic groups). When these nonpolar R groups and water face each other, a new more ordered arrangement is created. Thus, input of energy is required to face nonpolar R groups into water. However, a random polypeptide chain with its nonpolar R groups, tends to shield from the surrounding water molecules. The tendency of the surrounding water molecules is to relax into their maximum entropy state."that brings the transition of the polypeptide chain from a random in unfolded state to a highly ordered tertiary conformation".[6] At equilibrium state when the polypeptide chain is fully folded,increase in the entropy of the surrounding water molecules is greater than the decrease in the entropy of the coiled polypeptide chain. Evidently, the second law has not been violated because the combination of the system (the polypeptide) and the environment (water) has undergone a net increase in entropy.

Summing up the phenomena, the stability of a native globular protein is thus the result of a delicate balance

(6) Ibid

between two relatively massive and opposing forces :

1) The tendency of the polypeptide chain to unfold into a more random arrangement.
2) The tendency of the surrounding water molecules to seek their most random state(7).

These considerations have great significance for the ordering process.

2.2. Biocybernetics I - Adaptive Self-Stabilization

Biocybernetics I is defined by two components(8):

(i) Genetically programmed
(ii) Empirically acquired processes of self-stabilization.

These two components maintain the steady state of the organism through adaptation to the environment.

It has been emphasized that the 'openness' is the fundamental characteristic of organisms. The self-maintenance of complex systems in highly unstable steady states requires a constant openness of the systems' boundaries. for purposes of the exchange of matter and energy from the environment. This exchange is defined as metabolism. It consists of two

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(7) Ibid., p. 143.
(8) Laszlo, op. cit., p. 79.

stages:the breaking down and assimilation of the negentropic input (anabolism) and the output of the entropic waste products (catabolism). The degree and constancy of the openness of biological systems is a consequence of their steady state maintaining self-regulation in a state of thermodynamical disequilibrium. A steady-state is neither motionless, a true equilibrium,nor fully time independent. In function of time, the organism adopts new steady states. The time-bound changes are those which differentiate the normaley states of the embryo, the young, the mature and the aging organism. At each period, organism maintains steady-states by wide variety of processes, "some of which fall under the general heading of 'homeostatis' others under that of 'learning'"(9). Homeostatis is distinguished from learning by maintaining the existing organic structure through a genetic programming, whereas 'learning' maintains that structure by evolving behavior patterns based on individual experience.

Canon in 1939 proposed the term homeostatis to denote the self-regulation of organism, whereby maintain their needed constancies by adaptively balancing potentially noxious environment energies and stimuli. Homeostatis or self-regulation can be undertood as a cybernetical process involving the organism in an ongoing transactional relationship with its environment. In homeostatis, as in servo-

(9) Ibid., p. 74.

mechanisms, the output is chosen so as to minimize the deviation of the input from the system's organizational requirements.

The human body is actually an aggregate of about 75 trillion cells organized into different functional structures, some of which are called organs. Each functional structure provides its share in the maintenance of homeostatic conditions in the internal environment. As long as normal conditions are maintained in the intenal environment, the cells of the body will continue to live and function properly. Thus each cell benefits from homeostatis and in turn each cell contributes its share toward the maintenance of steady-states.

2.2.1. Genetically Determined Self-Regulation

There are two examples chosen to illustrate adaptive self-stabilization process. They are important because they imply;

(i) the nonlinearity and complexity of the control mechanisms

(ii) the control system does not act instantly instead requires a certain amount of time to develop its adaptation. Furthermore, the controlled variable often overshoots the final steady-state before it stabilizes

The first example is the allosteric enzymes, they are the best known regulating proteins. 'Allosteric' is a name proposed by J. Monod, J.P. Changeux and F. Jacob[9].

They are distinguished from ordinary enzymes. Like the latter, allosteric enzymes also recognize and bind selectively a particular substrate and catalyze its conversion into products. But these enzymes have a special property of recognizing selectively one or several compounds whose (stereospecific) association with the protein has a modifying effect that is - depending upon the case, it has the property of increasing or inhibiting its activity.[10]

Various "regulatory modes" are assured by allosteric interactions. The scheme of Monod will help to clarify the event.

1. Feedback inhibition - The enzyme which catalyzes the first reaction of a sequence whose end product is an essential metabolite (a constituent of proteins or of nucleic acids)[11][12] is inhibited by the final product of the sequence. The intracellular concentration of this metabolite governs its own rate of synthesis.

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(9) Monod and Changeux, Journal of Mol. Biol. (1965), 12, p. 88.
(10) Jacques Monod, Chance and Necessity (New York: Vintage Books, 1971), p. 63.
(11) Ibid.
(12) Any compound produced by metabolism is called metabolite. Essential metabolites are the compounds required for growth and multiplication of cells.

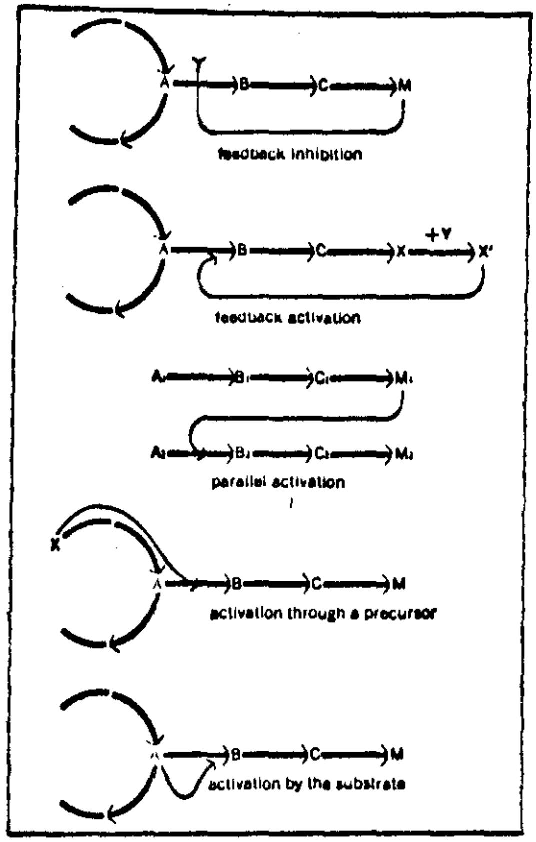

Figure 2

Arrows with solid lines symbolize reactions producing intermediate compounds (denoted A, B etc). The letter M represents the terminal metabolite, conclusion of the sequence of reactions. Fine lines indicate the origin and point of application of a metabolite acting as an allosteric effector, the inhibitor or activator of a reaction.

2. Feedback activation - The enzyme is activated by a product of degradation of the terminal metabolite. This regulatory pattern usually serves with metabolites whose high chemical potential constitutes a source of energy for the cellular machinery. By this way chemical potential is maintained at the prescribed level.

3. Parallel activation - The first enzyme of a metabolic sequence leading to an essential metabolite is activated by a metabolite synthesized by an independent and parallel

sequence. This mode of regulation contributes to maintaining a balance between metabolites belonging to the same family and destined for assembly in one of the classes of macromolecules.

4. Activation through precursor - The enzyme is activated by a compound which is a more or less remote precussor of its immediate substrate. This made of regulation amounts to keeping the 'demand' subordinate to the 'offer'.

5. Activation of the Enzyme by the Substrate Itself[13]

An allosteric enzyme may be subject to several modes of regulation at a time. "As a general rule these enzymes are under the simultaneous control of several allosteric effectors, antogonistic or cooperative"[14].

The second example is a macro level analysis, 'the glucose control system' will also delineate the complex mechanisms of homeostatis.

Guyton proposes a quantitative mathematical analysis for explaining the control systems.

The basic control system for regulating the glucose concentration in the extracellular fluids is the following:

(13) Ibid., p. 65.
(14) Ibid., p. 66.

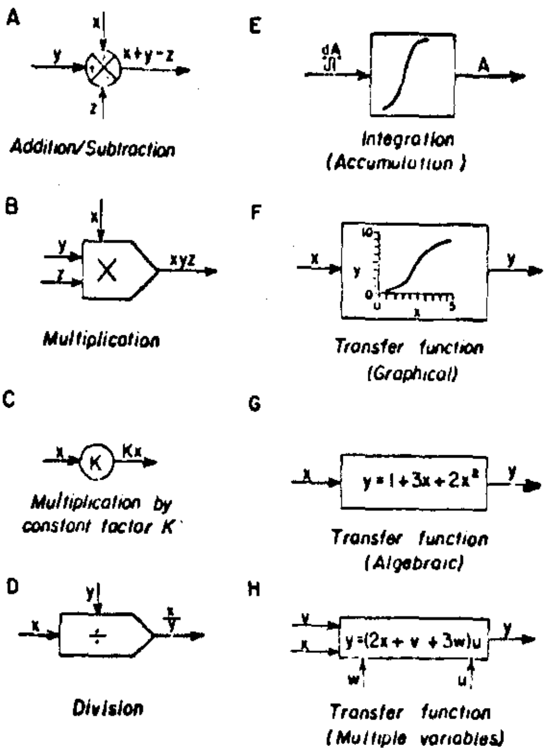

Figure 3

When a person eats incresed quantities of glucose, the rising glucose concentration in the extracellular fluids causes the pancreas to secrete increased quantities of insulin. The insulin, in turn, causes the increased transport of glucose through the cell membranes to the interior of the cells where the glucose is used for energy. This, obviously, returns the extracellular glucose back toward normal.

The figure illustrate the mathematical symbols, analysis introduced before hand. (Figure 3).

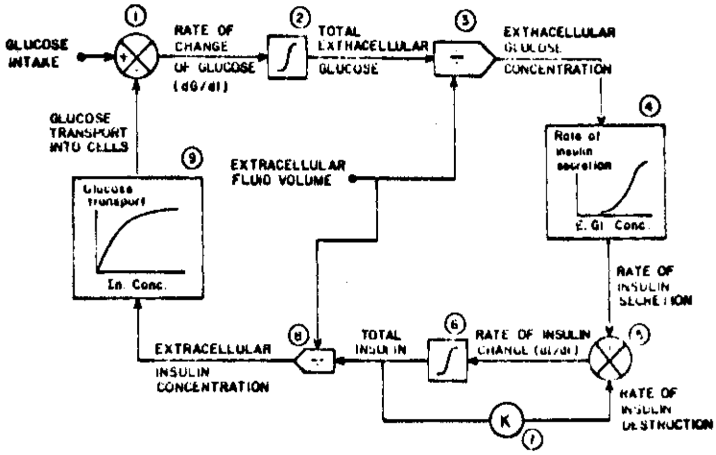

Figure 4: Analysis of the insulin control system for maintaining a contstant glucose concentration in the extracellular fluid. By this analysis it is possible to predict transient as well as steady-state changes in variables of the system such as the readjustments of the system after sudden changes in the rate of glucose intake.

1. Calculates the rate of change of glucose (dG/dt) in the extracellular fluids by substracting rate of glucose transport into the cells from the rate of intake glucose.

2. Integrates the rate of change of glucose with respect to time to give total extracellular glucose.

3. Calculates the extracellular glucose concentration by dividing the total extracellular glucose by the extracellular fluid volume.

4. Illustrates the effect of extracellular glucose concentration on rate insulin secretion.

5. Sums the rate of insulin secretion and the rate of insulin destruction to give the rate of insulin change (dI/dt).

6. Integrates the rate of insulin change to give total

insulin in the body at any one time.

7. Calculates the rate of insulin destruction by multiplying the total insulin by the constant K.

8. Calculates the extracellular insulin concentration by dividing total insulin by extracellular fluid volume.

9. Illustrates the effect of extracellular insulin concentration on the rate of glucose transport in the body cells.[15]

2.2.2. A Manifestation of Homeostatis

A special manifestation of homeostatis is reproduction, involves the cyclic degeneration and regeneration of individuals. Aging and death are balanced by birth and growth and the species maintains the organization characterizing its genotype. The control over these processes is exercised by information carried within the genes and only its actualization is conditioned by the environment. The genes carry the 'message' or 'instructions' for rebuilding the mature organism from the specialized reproductive cells, hence the growth process if not one of self-organization (morphogenesis) but simply self-stabilization (morphostatis)[16].

Waddington categorize growth and development under the concept of homeorhesis (Greek Rheo - to flow),

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(15) Arthur C. Guyton, Medical Physiology (London: Saunders Co. 1976), pp. 10-11.
(16) Laszlo, op. cit., pp. 74-76.

meaning that what is constant is not a stationary state but a flow process. Flow process of this kind follow relatively fixed trajectories which Waddington calls 'chreods', ('Chre' fated or necessary and 'hodos' path). For example, if disturbances cause a homeorhetic process to deviate from its normal course, its negative feedback control bring it back to not where it was disturbed, but to where it would have progressed if left undisturbed. The many intricate pro-- cesse as of growth from fertilization and embryogenesis, through birth and maturation, represent homeorhetic processes following more or less fixed chreods programmed into the organic system in virtue of its genetic structure and conditioned in its process of actualization by the environment it finds(17). A new structure may emerge having the 'instruc- tions' encoded in parents but according to Laszlo(18) the new structure does not signify reorganization and should not be confused with self-organization (which exemplified only in evolution.)

2.2.3. Learning

Clausse defines 'learning' as "knowledge, capacities, interests, attitudes, affective responses, social and idea- tional adjustments, techniques or thought and action which affects all aspects of personality". Continuing, he says that learning consists of

(17) Ibid.
(18) Ibid.

modification of behavior attained by the 'solution of a problem posed for the individual by his environmental relations"(19).

Learning does not presuppose a high grade awareness of one's own mental events (It does presuppose some degree of self-awareness on the other hand, since information must be received in the system of the success of its various subroutines before new routines can be evolved to improve them). In some cases, learning may be 'physiological' as contrasted with a 'psychological' process. The body can perform it even in the absence of a conscious awareness of what takes place. 'Visceral learning' is a striking example. The adaptive re-programming of certain homeostatis norms, heart-beat, kidney function, blood-pressure, blood-flow, intestinal and stomach contraction and even brain waves, may be amenable to regulation in function of an adaptive response of the organism as a whole to its environment.

N. Miller and his colleagues have shown that organisms can reorganize their genetically coded homeostatis norms as means of optimizing the frequency of the reward. (Having reached the goal). Although it is not clear by what processes, rats as well as human subjects can slow down, as well as speed up, their heart-beat rate, increase

(19) Laszlo, op. cit., p. 80.

and decrease their blood-pressure and blood-flow in the stomach walls. One thing sure about these processes is that the organism maximizes the rewarding (matching) input and avoids the punishing (mismatching) kind[20].

Learning represents in Thorpe's words "the process of adjusting more or less fixed automatisms or patterns of behavior and more or less rigid releasing mechanisms to the changes and chances of life in the world." It is based on a large preprogrammed network, in autonomic nervous system and its sensory-motor reflex arcs, which activates many varieties of reflex patterns. But learning signifies the supervention of empirically acquired patterns upon these genetically coded ones. The biological range of learning extends from organisms with relatively primitive nervous system capable of no more than minor adjustments of instictive patterns to organisms with highly evolved nervous system in whom learning can take the form rational and aesthetic insights.[21]

Thorpe classifies the varieties of learning under five leadings: habituation, conditioning, trial and error learning, latent learning and finally insight learning.

Insight Learning is a sudden production of a new adaptive response not arrived at in trial behavior; the

(20) Guyton, op. cit., pp. 768-778.
(21) Laszlo, op. cit., pp. 81, 82, 83.

solution of a problem achieved by the sudden adaptive reorganization of experience. For example, bees display this in direction-finding and orientation and many other examples[22].

In Thorpe's words; 'the work of recent years has, on the whole, confirmed ..... that all learning is in some degree the manifestation of a process basically identical with insight'. Adaptation leads to learning, and learning to some in sight, into the network of relations in which the organism finds itself. Insight, if sufficiently pronounced, becomes the foundation of empirical knowledge[23].

The chain of perfected adaptation thus leads, through perception, innate release mechanisms, motivated behavior and learning, to 'intelligence'. Intelligence according to Piaget "is not separable from instinct nor opposed to trial and error learning; it is the most highly developed form of mental adaptation, that is to say, the indispensable instrument for intereaction between the subject and the universe when the scope of this interaction goes beyond immediate and momentary contacts"[24]

Intelligence may be defined as the insight into, or grasp of, the relations which are relevant to the

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(22) Ibid.
(23) Ibid.
(24) Ibid.

compatibility of the organism with its environment. This definition is supported by Piaget's conclusion: "In fact every relation between a living being and its environment has this particular characteristics: the former, instead of submitting passively to the latter, modifies it by imposing on it a certain structure of its own"[25]. "Mental assimilation is the incorporation of objects into patterns of behavior, these-patterns being none rather than the whole gamut of actions capable of active repetition"[26]. Thus, through perception and behavior, objects are incorporated into patterns of behavior, and the relations of objects to the organism become explicated. As Thorpe emphasized, insight is the apprehension of relations, and the relations here involved are those which are relevant to the compatibility of the intelligent organism with its environment.

Intelligence, to judge from our species, crytallizes gradually and evolves in continuous elaboration from basic sensori-motor insight involved in manual and bodily skills, through symbolic-representative insight present in mechanical and technical reasoning, to abstract reasoning[27].

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(25) Ibid.
(26) Ibid.
(27) Ibid.

Adaptation, in learning as well as in biology general, is an active process of creatively responding to the challenges of the environment by a suitable modification of endogeneous activity patterns. It involves both 'accomodation' and 'assimilation'. That is, "any biological adaptation implies two poles ..... On the one hand, it is an 'accomodation' (by definition) a temporary modification of the organism's structures under the influence of external factors. But adaptation, even momentary, implies a complementary pole which, in general terms, could be called the 'assimilation' pole. ... Here, external factors are integrated into the organism's structures which necessarily implies a continuity between earlier and later structures. Thus, any reaction or response is the expression of its continuous structuralization due to the organism as much as it is due to pressures from the stimuli, the environment[28]. The two poles of 'adaptation' and 'assimilation' are present on all levels of development, organic as well as cognitive. Piaget concludes that "it is in the strictest sense of the word that knowledge is a special case of biological adaptation"[29].

Since the knowledge of an organism acquires lifetime, and can not be passed to succeeding generations, it is not

(28) Ibid.
(29) Ibid.

an evolutionary adaptation. In other words, learning is a temporary reorganizations of the parameters of the organism's essential functions, physiological as well as behavioral. "Not being heritable, the modifications leave the genotype inaffected and, when viewed in the perspective of species, they belong to the general domain of morphostatis rather than morphogenesis"[30]

Finally, the organism, an ordered whole, adaptively maintains itself in the states proper to its level of development, correcting for environmental perturbations both by purposive behavior response on the environment and by a limited temporal reorganization of its organic and behavioral parameters to compensate for persistent disturbances[31].

2.3. BIOCYBERNETICS II
ADAPTIVE SELF-ORGANIZATION

Homeostatis or adaptive self-stabilization is defined as organism's adaptation to the environment by means of negative feedback and self-regulation which is controlled by genetic programming that is heritable. These genetic codes represent the norms of the organism, they are fixed internal constraints. Learning can effect a temporal reorganization of the norms through new and

(30) Ibid.
(31) Ibid.

flexible behavior patterns, but the reorganizations are not heritable.

Adaptive self-organization or evolution signifies the reorganization of the 'very' structure of the the system. The 'very' structure is the genotype of the organism. Darwin defined evolution as "descent with modification". Evolution or phylogenesis stated in another way, is the process by which related populations diverge from one another, giving rise to a new species (or higher groups). It consists of mutations exposed to the test of natural selection, and the changes are not only in the behavior pattern (and insight) or the organism, but in its genes.

Neo-Darwinism has three basic postulates explaining evolution:(32)

(i) the process of mutation yields the genetic raw materials

(ii) evolutionary changes are constructed from these materials by natural selection

(iii) in several organisms, reproductive isolation makes the divergence of biological species irreversible

Evidently, any theory of evolution must account for the origin of genetic changes. Two types of ge-

(32) Dobzhansky and Ayala (ed), op. cit., p. 42.

genetic changes are known: Mutation and recombination of genetic materials.

From the cybernetic point of view, the processes of evolution like learning, are positive feedback, 'deviation amplification' processes activated in response to a need for adaptation to the conditions in the environment. According to Maruyama "The deviation counteracting mutual causal systems and the deviation amplifying mutual causal systems may appear to be opposite types of systems. But they are both mutual causal systems i.e. the elements within a system influence each other either simultaneously or alternatingly. The difference between two types of systems is that the deviation counteracting system has mutual negative feedbacks between elements in it while the deviation amplifying system has mutual positive feedbacks between elements.[(33)] " ..... Both fall under the subject matter of cybernetics ..." The deviation counteracting mutual causal process is also called morphostatis, while the deviation-amplfying mutual causal process is called morphogenesis"[(34)].

Maruyama lists four different categories of deviation-amplifying positive feedback processes occuring in phylogenetic evolution.[(35)]. First, there are positive

(33) Maruyama, "The Second Cybernetics: Deviation Amplifying Mutual Causal Processes", Buckley (ed), op. cit., p. 304.
(34) Ibid.
(35) Ibid.

feedback processes between mutations and the environment. The selection of a certain type of environment whether by accident or design, favors certain types of mutants. These in turn favor certain features of the environment and these features determine the viability of new mutants. Thus a kind of vicious circle which amplifies the original deviation is obtained. Second, there are interspecific deviation amplification. The increased protective ability of one species of mutants calls for increased detection ability and hunting techniques of its predators. Such ability in turn favors mutants with still greater protective abilities and so on. The responsive abilities of the species in the food chain amplify each other and increase generation after generation. Third, intra-specific selection can be deviation amplifying. Certain individuals may prefer stimuli of specific kinds, leading to the selection of mates and collaborators of particular kinds. By giving more responses to these stimuli, the members of a species can amplify the original deviation, found in the deviating individuals chosen for mating and cooperation, by producing more offspring of such characteristics. Such preferences may be inborn as well as culturally conditioned. Finally inbreeding, can be deviation amplificative since the characteristics of the inbreeding population can be amplified in successive generations. If families would not intermarry, each family would develop into a separate species, amplifying its distinguished characteristics.

Interbreeding, on the other hand, has a stabilizing effect, in eliminating predominant tendencies toward specific characteristics[36]. The individual apart from population has no control over the processes, it is the population which is evolving, although the effect of the evolution is demonstrated in each of its individual members.

Phylogenetic evolution is a selective progression toward the organization capable of handling all possible types of fluctuations in the environment. It is effected through mutations, which are exposed to the test of survival (natural selection) with the result that the fittest i.e. the best adapted to existing conditions survive and propagate. The terms 'fittest' and 'natural selection' have specific meanings. The 'survival of the the survivors' i.e. a tautology, because under 'fittest' we understand an organism with a specific level of adaptive organization from which it defacto results that it tends to survive longer and propagate itself more extensively than less adapted organisms. Also, 'natural selection' is not a brute external force weeding out less adapted organisms as in classical Darwinism, but denotes an adaptive system-environment process. It is comparable, in Dobzhansky's words; "not to a sieve but to a regulatory mechanism in a cybernetic system"[37]. The genetic endowment of a living species

(36) Ibid.
(37) Dobzhansky, op. cit., pp. 39, 307, 309, 339.

receives and accumulates information about the challenges of the environment in which the species lives. The evolutionary changes are creative responses to the challenges of the environment. Dobzhansky reiterates saying "Natural selection constitutes a bond between the gene pool of a species and the environment. It may be compared to a servomechanism in a cybernetic system formed by the species and its environment. Somewhat metaphorically, it can be said that the information about the states of the environment is passed to and stored in the gene pool as a whole and in particular genes. Yet the environment does not ordain the changes that occur in the genes of its habitants"(38). In other words, natural selection is the preservation of the creatively responding mutant over other species who have not met the challenge to an equal degree. Toynbee described the situation simply as 'challenge and response'. A response will not occur if genetic raw materials are not available.

Dobzhansky's synthesis postulates that the natural selection is an ordering factor, an antichance agent, maintaining correlation between the organisms and their environment. Consequently, natural selection can be described as an ordering process which brings design out of randomness.

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(38) Ibid.

The general formula proposed by Laszlo will be illuminating(39):

external forcings + internal constraints ⟶ adaptive self-organization

"Biological evolution from systems point of view appears to be a process of adaptive self-organization whereby populations of biological system fit themselves into their environment and fit the environment to their intrinsic constraints and in so doing organize themselves to progressively unstable, yet increasingly functional states"(40). The basic concepts of random mutations and subsequent natural selection are not discarded but integrated within the wholistic context of evolving systems populations.

2.3.1. Evolutionary Progress

Seen in retrospect, evolution as a whole doubtless had a general direction, from simple to complex, from dependence to relative independence of the environment, to greater and greater autonomy of individuals, greater and greater development of sense organs and nervous systems conveying and processing information about the state of the organism's surroundings and finally greater

(39) Laszlo, op. cit., p. 94.
(40) Ibid.

and greater consciousness. Evolution exhibits a direction or trend. Prigogine put distinctively; "Wherever we look, we discover evolutionary processes leading to diversification and increasing complexity"[41].

Actually, it is not easy to establish the 'direction' of evolution without specific references or identifiable, quantifiable variables. Simpson attempted to categorize the direction of evolutionary progress:"dominance; invasion of new environments; replacement; improvement in adaptation; adaptibility and possibility of further progress; increased specialization; control over the environment; increasing structural complication; increase in energy or maintained level of vital processes; and increase in the range and variety of adjustments to the environment"[42].

Since adaptive reorganization tends to result in the complexification of organic structures, "it involves both an overall decrease in the level of intrinsic stability of the typical evolving organism, and a greater functional capacity to cope with the changes and challenges of the environment"[43] said Von Bertalanffy. As a result, smaller populations are more vulnerable but more efficient organisms, compensating for their inherent instabilities of structure through highly evolved cybernetic functions.

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(41) Ibid.
(42) Ibid.
(43) Prigogine quoted in Hayek, op. cit., p. 158.

However, degree of adaptation can be measured by four different and at the same time, related criterias:

(i) expansion in the number of kinds of organisms, that is species, diversification,

(ii) expansion in the number of individuals

(iii) expansion of the total bulk of living matter

(iv) expansion in the total rate of flow of energy.

'Every living thing' said Bertrand Russel 'is a sort of imperialist, seeking to transform as much as possible of its environment into itself and its seed'(44). Consequently, the total flow of energy in the living world has probably increased through evolution even faster than the total bulk of matter. Green plants, store radiant energy from the sun which otherwise would be converted to heat, but animals dissipate energy, as their catabolism exceeds their anabolism. Alfred Lotka was first to relate energy-flow through and biological evolution. Lotka said that every species can be described as a different type of transformer for capturing and using available energy(45). He argues that natural selection favors those organisms that are able to "increase the total mass of the system, rate of circulation of mass through the system, and the total energy flux through the system ..... so long as there is presented an unutilized residue of matter and

(44) Rifkin, op. cit., p. 53.
(45) Ibid., p. 55

available energy"(46).

However as various species begin to fill up a given ecological environment, they are forced to adapt to the ultimate carrying capacity of the environment by using less energy flow-through more efficiently. Rifkin emphasizes that each succeeding species is more complex and thus better equipped as a transformer of energy. Consequently, the energy flow will be greater with more energy being unavailable. According to second law of thermodynamics, evolution creates "larger and larger islands of order at the expense of even greater seas of disorder in the world"(47).

Prigogine also points out that the more complex the dissipative structure, the more integrated and connected it is, and thus the more energy flow through it requires to maintain itself. Noting that the flow of energy through a dissipative structure causes fluctuation, and he concludes that if the fluctuations become too great for the system to absorb, it will be forced to reorganize. Prigogine then asserts that reorganization always tends toward a higher order of complexity, integration and connectedness and greater energy flow through. Each successive reordering, as it is more complex than the one

(46) Ibid.
(47) Ibid.

precceeding is, it even more vulnerable to fluctuations and reordering and speed-up of evolutionary development and energy flow-through. Prigogine equates instability with flexibility and with mathematical formulas, he attempts to show that the more complex and energy-consuming the system is, the more flexible and adaptable it is(48).

So far, evolution is explained in terms of complexity. (Von Bertalanffy, Prigogine, ...). In fact, 'complexity' is itself a complex concept. In a way, animals are more complex organisms than plants. In another way, the photo-synthezing apparatus of plants which animals lack, is more complex. Also some evolutionary changes are toward smaller size and some parasites have become more simple, than their ancestors. They only sure thing that can be said about the 'direction' of evolution is that "at any given time it is toward a better adaptation to environment in which a class of life is immersed at that time, the adaptation being insured by natural selection," said Rapoport(49).

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(48) Ibid., p. 241.
(49) Anatol Rapoport, Conflict in Man-Made Environment (Middlesex: Penguin Books, 1974), p. 65.

... Before us lies a search for pattern in individuality, for unity in diversity.

James G. Miller

Living Systems

III. SOCIETY AS A COMPLEX ADAPTIVE SYSTEM

This chapter views social systems or organizations, and seeks answers to the question whether we can describe order in social systems or organizations in the same way as we describe it in biological systems or organisms. The main section headings are: Organizations Defined, Organizations from the Cybernetic Point of View, Organizations Surrounded by Man-Made Environment.

The first section attempts to define organizations and tries to summarize different interpretations of organizations.

In the second section, Kuhn's cybernetic model of the organizations is applied. The survey mainly emphasizes the informal organizations their implications and specificly attempts to answer if an informal organization such as market order could be viewed as 'natural'.

The third section involves organizastions surrounded by man-made environment concentrates on distinguishing the properties of social systems from biological systems. In other words, it is the comparison of the 'environments'. Consequently, the section stresses whether cultural evolution could be an anolog of biological evolution.

The final section overviews the concepts, differentiation and complexification and their relevancy to entropy. Also the interpretation of social evolution in included within the final section.

3.1. Organizations Defined

The concept 'organization' covers a multiplicity of meanings:

Cyert and March defined organization as a complex social unit deliberately designed to achieve a specific purpose or set of purposes. They pictured an organization as a coalition of individuals, some of whom are organized into subcoalitions. The coalition is defined as a group of individuals that agree to participate in the organization or suborganization. Each coalition has goals that result from a continuous bargaining-learning process. Coalitions are complex social units, and the bargaining process represents a concept of deliberate design. By bargaining what meant is verbal and nonverbal interactions the coalition members to specify and change the organization's objectives. The outcome of the bargaining within the particular coalition is a purpose or set of purposes that gives the organization momentum, direction and identity(1).

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(1) Cyert and March quoted in Kevin Knight and Ronald Mc Daniel, Organizations and Information Systems Perspective (California:Wadsworth Publishing Company Inc., 1979), p. 5.

Another definition is by S. Beer:

"I define organization as a structural device for reducing proliferating variety. By this I mean that when a large and complex system has been segregated into subsystems, it losses the appropriate combinational power to become more complicated still".

And continues:

"Sensible attempts to institute horizontal cross linkages in a vertically compartmentalized system of this kind are - and in a sense very properly - resisted, because they would restore the variety generating capability that the organization as such is meant to destroy. But it is a necessary corollary of this that everything we do is constrained in its effectiveness by the appropriateness of the divisions we made in the first place. Since our circumstances, and above all our technology, are so rapidly changing, the likelihood that particular organizational divisions that were once effective will remain so is very low indeed"(2).

W. Ross Ashby delineated 'the hard core of the concept is, in my opinion, that of 'conditionality'. As soon as the relation between two entities A and B becomes conditional on C's value or state then a necessary component of "organization" is present. Thus the theory of organization is partly co-extensive with the theory of functions of more than one variable. ...

"... The treatment of conditionality (whether by functions of many variables, by correlation analysis, by uncertainty analysis, or by other ways) makes us realize that the essential idea is that there is first product in space - that of the possibilities - within which some sub-set of points indicates the actualities. This way of looking at 'conditionality' makes us realize that it is related to that of communication; and it is of course quite plausible that we should define parts as being organized when communication occurs between them"(3).

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(2) Stafford Beer, Platform for Change (London: John Wiley and Sons, 1975), pp. 34-35.
(3) Ashby, Principles of Self-Organizing System (New York: Pergamon Press), pp. 255-278.

Much organizational research conducted by scholars like Max Weber, Friedrick Taylor, Luther Gulick, Lyndall F. Urwick, Elton Mayo, Philp Selznick, Parsons, Herbert A. Simon, Alvin Gouldner, Robert K. Merton ... have been concerned with the formal organizations and their effectiveness and productivity. Beginning with Max Weber different point of views are classified under the headings such as rational, classical, human relations, natural, conflict, exchange, technological and open systems perspective. For example rational perspective can be illustrated by these propositions.

(i) organizations which have a single goal are more likely to have a high degree of effectiveness than organizations which have multiple goals.

(ii) organizations which have a high degree of goal specificity are more likely to have a high degree of effectiveness than organizations which have a low degree of goal specificity.

(iii) organizations which primarily have a rational-legal type of decision making are more likely to have a high degree of effectiveness than organizations which are primarily have a charismatic type of decision making.

(iv) organizations which have a high degree of legitimacy are more likely to have a high degree of effectiveness than organizations which have a low degree of legitimacy.

(v) organizations which have the maximum degree of centralization with respect to strategic decisions are more likely to have a degree of effectiveness than organizations which do not have the maximum degree of centralization with respect to strategic decisions[4].

A discussion of an 'organization' in terms of their effectiveness or productivity, which is related to their conceptualization as goal-oriented, consciously designed systems,need not detain us any longer. In respect of the kind of inquiry pursued in this thesis, we have adopted a somewhat more general definition of an organization. It will be recalled that our definition of an organization was stated as 'any system that consists of two or more interacting beings"[5]. This definition is put forward by natural system theorists and later elaborated by general system theorists as an open systems perspective.

Viewing organizations as interaction systems provides a variety of highly useful concepts and analysis of its own, notably about feedback, error-correction and steady-state equilibrium[6] all updated continuously, which is affirmed by S. Beer 'For the first time in history there is an explicit need to continuously update the models we are using"[7].

(4) Haas and Drabek, Complex Organizations (New York:Macmillan Company, 1973), pp. 23-24.
(5) See Introduction p.
(6) See Cybernetics Section
(7) Kuhn, op. cit.

The main points of 'interaction systems' can be summarized:

First, interaction refers to a process of mutual and reciprocal influencing by two or more persons. Interaction may be verbal, nonverbal, spoken, written and so forth. In highly technological system, most interaction is indirect. Men on an assembly line, for an example, may be viewed as an interaction system even though they might never speak to one another verbally. Thus, includes a highly patterned set of events. Behaviors by A influence B's behavior, which in turn influence C and so on.

Second, organizations are more than simple additive sum of their parts. This property has been emphasized throughout the thesis. A unique series of inter-dependent relationships that exist between the parts that characterize the whole. The key feature is the emergent properties. For example - if all the parts of the automobile were laid randomly, one would not have an automobile. Thus the characteristics of the functioning whole, can only be described by the relationships between the parts, the whole and the environment .

Third, in all organizations, the components are interrelated, so that a change in one will cause changes of various types of others; neither the intensity nor type of changes caused are uniform throughout. Many of the changes may be indirect. Hence, organizations are viewed as open systems being an interaction system in a constant state of flux.

It will be recalled that whenever two or more persons interact, it is defined as s system[8]. Because it involves multiple persons, such a system is also social. If the interaction produces no noteworthy joint effect that is more than the sum of the effects on the participating individuals, the interaction is regarded as simply an interaction, not a system in its own right. However if some additional result that seems worthy of attention does come out of the interaction, the interaction may properly be construed to be a system. Thus, the production of joint effect is what makes an interaction system as well as an interaction. The production of joint effect by two or more persons is also the definition of organization in the model presented in 'cybernetics'[8]. Hence, social system and organization is synonymous.

As it was mentioned in the 'cybernetics' section[8] if the actions of two or more parties are consciously coordinated toward a joint effect, the organization is formal. It is informal if the

(8) See 'Cybernetics', p. 38.

> "joint effect is produced without conscious coordination as when the separate and self-oriented actions of several neighbors to maintain their own properties create the joint effect of an attractive neighborhood that enhances the property values of all"(9)

In other words, an informal organization is created, when a continuing or repeated and reasonably stable pattern emerges from the joint effect or the separetely decided behaviors of two or more persons (coordinated by communications and transactions or by instruction). It involves mutually contingent, separate decisions but not aggreement on the same decision. Implications of the informal organizations will be discussed later in this chapter.

3.2. Cybernetics Applied to Social Systems

In the cybernetics chapter(10) the concepts detector, selector, effector, communication, transaction and organization were presented. An organization is defined as the joint effectuation of a result. Organizations are distinguished as formal and informal, whether they are controlled or uncontrolled respectively. Formal organizations are identified by the conscious or deliberate coordination of behaviors of parts into behavior of the whole. In other words, the whole system is controlled, goal-oriented or serve to a 'concrete purpose'. Hayek proposes the term 'made order' or 'taxis' for formal organizations(11).

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(9) Kuhn, op. cit., p. 17.
(10) Chapter 1, Section 1.3.
(11) Hayek, op. cit., pp. 35-54.

In this section, informal organizations 'spontaneous order' or 'cosmos' will be discussed. Informal organizations are identified as not being consciously coordinated toward a concrete purpose. In other words, it is an uncontrolled system of interacting controlled subsystem, in which the controlled subsystems are individual human beings, formal organizations or some combination. That is, the whole of the system is not controlled or consciously or deliberately designed to serve any purpose. The whole of the system is uncontrolled by individual goals; expectations make up the subsystemic controls of the system. Each subsystem individual or formal organization pursues its own self-oriented goals. The joint effect of the subsystems' activities falls where it will. Any coordination that produces a joint effect is wholly unconscious. No sub-system behavior is performed in order to produce the joint effect, but that does not necessarily mean a complete 'unawareness' of the subsystem about the whole.

Hayek describes informal organizations as "spontaneous orders" or 'cosmos' as self-organizing and self-generating, He conceives that "the order as such also have no purpose, although its existence may be very serviceable to the individuals which are within such order" ... "the elements have acquired regularities of conduct conducive to the maintenance of order-presumably because those who did act certain ways had within the resulting order a better chance of survival than those who did not"(12).

(12) Ibid., p. 39.

Natural system perspective theorists Michels, Parsons and Selznick have also viewed organizations much like biological organisms continually changing in efforts to cope with environment modifications. Also most changes are not based on planning and even planned changes are recognized to come up with many unanticipated consequences.

Ecosystems and the market order are the best known examples of informal organizations. "Because there could hardly be conscious coordination toward a non-existent goal, the absence of any whole-system goal itself implies the absence of conscious coordination"(13). Thus the absence of conscious coordination and attention to sub-system goals are the main identifying criteria of 'informality', 'spontaneity' and 'cosmos'. A pure informal organization has no supersystem goals or control mechanisms at any level of the whole system(14).

Thus informal organizations do have goals but it should be recognized that every structure has a set of basic needs and develops systematic means of 'self-defense'(15). Most of the behavior observed within informal organizations are not specifically goal-directed, but are attempts to meet these needs so that equilibrium can be maintained or restored.

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(13) Kuhn, op. cit., p. 184.
(14) Ibid.
(15) Haas and Drabek, op. cit., p. 51.

Consequently, informal organizations are a collection of subsystems. In constast to an efficient machine designed to attain a single, clearly defined goal, there are competing systems within systems, each trying to maintain its own equilibrium, each fighting for survival.

Selznick, also proposes that the higher the degree of autonomy in relationship with the environment The more likely they are to survive than those who do not, Hence, all subsystems within organizations are constantly trying to change their structures so as to increase their autonomy[16]. Kuhn also conceives that when a contuining or repeated and reasonably stable pattern emerges from the joint effect of the separately decided behaviors of two or more persons (coordinated by communications and transactions or by instruction), then this relationship constitutes an informal organization. "It involves mutually contingent separate decisions but not agreement on the same decision"[17]. The logic of the market order is in accordance with informal organizations. There are many producers and exchangers of many goods. The mutual contingency is many sided and "each party makes its self-oriented decisions indepentently but with environmental contraints that consists of the joint effect of everybody else's decisions"[18] ... "The

(16) Ibid.
(17) Kuhn, op. cit., p. 192.
(18) Ibid.

difference is that between my being affected or constrained by what you do and my having to get your agreement to what I do"[19].

Apart from market order, if the government would not interfere ethnic groupings, population dynamics, status groupings and strafications are also examples of informal organizations named as human ecology. Ecological systems as defined before are systems with at least some of whose components are controlled systems. An example is an ecological system preserved by soil nutrients, temperature, rainfall and by farmers and industrial firms studying pollution.

Ricardo's 'natural price' and Adam Smith's 'invisible hand' are interpreted as economic cybernetic systems. Both views emphasize homeostatic properties of the market, and likened society as a competitive ecological system.

The competitive exclusion principle states that in a finite universe, and the organisms of our world, where the total number of organisms of both kinds can not exceed a certain number, a universe in which a fraction of one living organism is not possible, one species will necessarily replace the other species completely if the two species are 'complete competitors' i.e. - live the same kind of life[20].

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(19) Ibid.
(20) Buckley, op. cit., p. 451.

Only if the multiplication rates of the two species are precisely equal, will the two species be able to coexist. Finally, it is asserted that the "coexistence of species can not find its explanation in their competitive equality"(21). This theory leads to the predictors contrary to the fact. If we assume every species competes with other species, there would only be one species left which is the best. However, both in ecological system and in market system there exist millions of 'species'. The fact is explained, by geographic isolations, ecological succession or product differentiation, inter-breeding or mergers and by some other factors. As a result 'variety' survives. Before going any further, it should be noted that merits and demerits of market system is beyond the thesis scope. The attempt is only to explain the informal organizations from the cybernetic point of view.

The whole complex phenomena of informal organizations (uncontrolled system with control subsystem) contains negative feedback, homeostatis mechanism as well as positive feedback or Maruyama 's 'deviation amplification process'.(22)(23) Negative feedback in regarded as stabilizing factor or even be called as 'egalitarian' whereas positive feedback is defined in terms of evolution. Positive feedback moves the system from the established cybernetic or 'natural' equilibrium to another state.

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(21) Buckley, op. cit., p. 451.
(22) See Cybernetics Section, p. 32.
(23) See Biology Chapter, p. 76.

It will be recalled that Hayek's economic thought is in accordance with cybernetic, self-regulating mechanisms, as in his general view 'spontaneous order', and he belives economic discoordination results always from institutional factors. He conceives that if ever any large scale disequilibrium is created, it is just because that the market is not wholly unhampered. Hayek's view of equilibrium is a process in which men's plans are coordinated by trial and error over time, it is a kind of 'rational assesment', knowledge generalization and utilization. However, he seems to ignore, the positive feedback or deviation amplification and their unintended complex consequences leading to disequilibrium in our man-made environment. Social 'power' is a matter of positive feedback. Positive feedback or deviation amplification process , instead of correcting or offsetting a deviation, adds to and augments it, pushing the sytem even further in the direction of initial deviation. It may also be called a vicious cycle in the case of undesired deviation, "It can go upward in explosive fashion if the initial deviation is upward and downward in successively greater shrinkage the initial deviation is downward"(24).

Shackle's critique of Hayek will be connective at this point. Shackle sees market order as a result of creative imagination 'a matter of animal spirits'(25) and

(24) Kuhn, op. cit., pp. 50-51.
(25) John Gray, Hayek on Liberty (New York: Basil Blackwell, 1984), p. 92.

irrational rather than rational assesment as Hayek conceived it to be. Shackle's view is that a large-scale of economic collapse could occur in the absence of any governmental intervention. This is a powerful objection to Hayek's views which support unregulated market processes. Shackle conceives that disequilibrium is created by the divergency of subjective expectations, tastes, beliefs, which continually and unpredictably mutate. Hence, man creates its own man-made environment and equilibrium tendencies may result asymptotic, never quite reaching equilibrium with each of them soon overtaken by its successor. In other words, it is again a matter of positive feedback; man and his man-made environment develop paralelly. Boulding said that the 'population of man and artifacts expands indefinetely' (26) At the extreme, the system may strive to a point which is further away from competitive equilibrium. For an example, at macrolevel analysis, it is proved that capital accumulation is subject to positive feedback, in that the larger capital one has, the easier to acquire still more capital. It also explains why underdeveloped countries or infant businesses often find it so desperately difficult to do want developed nations established businesses do with ease.

This view is in accordance with the second law of thermodynamics. Quoting from Angrist and Hepler, "Each localized, man-made or machine made entropy decrease is

(26) John E. Behnke, (ed), Challenging Biological Problems (New York: Oxford University Press, 1972), p. 369.

accompanied by a greater increase in entropy of the surroundings, thereby maintaining the required increase in total entropy"(27).

Positive feedback creates an order at the expense of creating even greater disorder at some other part, distinguished by sharp discrepancies within the system(28)

The final remark I want to make is that the classical market should not be called 'natural' referring to the biological model of homeostatis, for it is truly human invention however unconsciously made. It is not universal; it has been modified continually as men groped toward better solutions. Although they are pessimistic Hayek's words are clarifying: "we have never designed our economic system, we are not intelligent enough for that"(29).

3.3. Organizations Surrounded by Man-Made Environment

In the previous chapter, biological systems are conceived as open systems. Social systems can also be analyzed accordingly. Although stability in societies is a key phenomenon, capacities for change likewise present, whether a society changes or maintains the status quo depends on whether its control resources are capable of

(27) Rifkin, op. cit., p. 44.
(28) See, Introduction and Second Law of Thermodynamics.
(29) Hayek, op. cit., p. 158.

dealing with changes in the environment by buffering them through the internal accomodation or whether dealing with disturbances entails a fundamental reorganization of the institutional and value structure. This switch from self-stabilizing negative feedback to self-organizing positive feedback parallels control processes in all levels of systems, and constitutes the dynamics of open systems. Stated in another way both stability and change are the function of the same set of variables, includes the internal state of the system and the environment and the interchange between two.

Buckley[30] proposes a paradigm 'complex adaptive system' to explain the capability of both self-stabilization and self-organization of the society. He emphasizes that 'sociocultural systems are open and negentropic;', that is they are open internally (subsystem) as well as externally (suprasystem). This structure makes the interchanges among their components possible and may result in significant changes in the nature of the components themselves with important consequences for the system as a whole. Besides pure energy interchange he emphasized an information flow (that is why he called negentropic) and feedback control as necessary elements of self-stabilization and self-organization, Such that "the system may change or elaborate its structure as a condition of survival or viability"[31].

(30) Buckley, op. cit., p. 490.
(31) Ibid., p. 490.

> To quote "the paradigm underlying the evolution of more and more complex adaptive system begins with the fact of a potentially changing environment characterized by variety of constraints, an existing adaptive system or organization whose persistence and elaboration to higher levels depends upon successful mapping of some of environmental variety and constraints into its own organization on at least a semi-permanent basis"(32).

Cadwallader proposes the term 'ultrastability' to illustrate the capacity to persist through a change of structure and behavior(33).

Parsons lists both exogeneous and endogeneous sources of structural change. Exogeneous sources include disturbances introduced to the system from the personalities, organisms and culture systems of its members which also constitute the man-made environment. It can be both national or international, but impetus for change is not within the social system. He identified endogeneous source of change under the concept 'strains'(34) (which doesn't concern us any longer).

In social systems the environment has unique properties. Unlike biological organisms, man is considered as the least dependent on his physical environment, but 'learning' - (whether biological or artificial in origin) captures him in another kind of environment which is the product of his own activity; it is the man-made environment or culture.

(32) Ibid., p. 491.
(33) Ibid., p. 437.
(34) Laszlo, op. cit., p. 107.

Man-made environment is also never constant. As cultural norms change, and evolve, personalities and ideologies replace one another. Dynamics of the environment can be described not only in terms of cooperation, conformity to norms, but conflict, competition and deviation as well.

Culture can be described as the accumulation of experience and knowledge over generations[35]. And culture constitutes an environment with which only human beings can interact. Like any animal or organism adapts its environment, human beings adapt to the man-made environment or culture. It consists of both material things (dwelling, tools, weapons, clothes etc) and non material components (language, customs, attitudes, beliefs, aspirations, laws, ways of perceiving the world). Animals may also create a material environment, but, as far as it is known, no animal creat culture in the full sense of the word[36]- "accumulation of collective intelligence through the accumulation of experience across generations."

Hayek describes cultural evolution as

"the structures formed by traditional human practices are neither natural in the sense of being genetically determined, nor artificial in the sense of being product of intelligent design, but the result of winnoving and sifting directed by the differential advantages gained by groups of practices adopted for some unknown and perhaps purely accidental reasons"(37).

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(35) Rapoport, op. cit., p. 50.
(36) Ibid., p. 50.
(37) Hayek, op. cit., p. 155.

Hayek's idea of cultural evolution is similar with Dobzhansky's "evolution, not a sieve"(38) in the sense that they both propose mutual interaction with the environment and some chance element. The formula can readily be applied to the situation.

$$\text{internal constraints} + \text{external forcings} \longrightarrow \text{adaptive self-organization}$$

However, biological evolution can not be an analog for cultural evolution. Because there are many distinguished characters of cultural evolution. The first outstanding fact about cultural evolution is the rapid rate of change. For example, two human beings are born 10.000 years apart. Anatomically and physiologically they would not have any astonishing dissimilarities but cultural contrast can easily be observed.

George Simpson stated that, biological evolution is 'oppurtunistic', that is variations can occur only in whatever already exists. The general rule of changes in adaptive mechanism is more and better of the same'(39). And each innovation must wait until the next 'deal' of genetic material. Learning as explained before(40), may improve the conditions of survival but never genetically transmitted.

(38) See Biological Systems.
(39) Rapoport, op. cit., p. 67.
(40) See Biology Chapter, p.

On the other hand, cultural evolution is not only independent from genetic changes, but also able to transmit the accumulated knowledge across generations. Consequently, increases the rate of evolution.

Cultural evolution can also be described as 'opportunistic'. Because each innovation is reminant in culture and selected if it is 'successful'. But, here, the analogy of Social Darwinism may be misleading, because, natural selection operates via selection of individuals according to their innate, genetic constituents, rather than culturally accumulated capacities of individuals. Cultures have been known to keep the steady-state for centuries, which can be an evidence 'fitness'. But, in the mean time, hardly any culture is in a steady-state. Cultures are not readily identifiable as biological species, as it is an abstraction. Consequently, it is a matter of judgement to interprete whether a culture evolves or decays. The 'phenomena' may appear to some historians or antropologists as a 'development' of culture, where as the other historians and antropologists may interprete as a 'decay'. Evidently, "the lines of biological evolution, descent, in principle, clearly traceable. Those of cultural descent are not"(41).

"Culture is the totality of man-made objects, rules, expectations, patterns of behavior and interaction,

(41) Rapoport, op. cit., p. 69.

attitudes, and beliefs that constitute a man-made environment of a group of human beings"(42). All the items of culture are reproduced, and evolves via the variations in its items, , and selection operates on these variations. Material components are reproduced by being copied. And non-material components are reproduced by being initiated or symbolically (language) transmitted through generations.

Evolution is a matter of positive feedback. In other words, there wouldn't be evolution in homeostatic, equilibrial systems. The changes reinforce each other, each innovation is a consequence of the preceeding innovation. In biological evolution, there is a 'control' element; the adaptation of evolving type to the environment. A particular form of adaptation may lose its survival potential because of changes in the environment. If so, a species may become extinct or 'change direction' to adapt to the new environment. "Sustained counter-adaptive direction is not possible in biological evolution"(43).

Whereas, in cultural evolution, there is no 'control' element. Changes are developed concurrently with culture. That is, "changes are incorporated into a culture"(44). In this connection Hayek states that "mind and culture developed concurrently and not successively"(45). It is a matter of

(42) Ibid., p. 72.
(43) Ibid., p. 76.
(44) Ibid., p. 76.
(45) Hayek, op. cit., p. 156.

positive feedback. We create our environment. So the adaptations are made to our man-made environment, and "there is no guarantee that these adaptations enchance the survival potential of the culture"(46).

Another point to be emphasized is the consequences and interpretation of the changes in the cultural and institutional norms of the system, that is a change in the structure itself, which is analyzed under the concepts, 'specialization' and 'complexity'. Eisenstadt proposes the term 'differentiation'. Actually the content remains significant that is to grasp the evolutionary self-organizing trends and processes in social systems. He stated that

> "The process of functional differentiation is one of the fundamental types of social change, and has evolutionary aspects and implications. In its bearing on the type of the system, it involves more than increasing complexity, - e.g. the fact that flexible disposability of resources depends on such differentiation. This dependence requires higher order mechanisms of integration substuting the more specialized processes of control associated with markets, power systems, etc., for control through embeddedness in diffuse structures"(47).

Progressive differentiation can be described in terms of the evolution of primitive kinship societies with simple division of labour develops to complex modern societies in which the main roles are institutionalized and organized in specific symbolic and organizational frameworks which become increasingly interdependent and symbiotic in their

(46) Rapoport, op. cit., p. 76.
(47) Laszlo, op. cit., p. 108.

functioning within the integrated social system.

Different societies arrive at the same level of differentiation through different historical paths and through diverse structural forms. The process, such as modernization may start in tribal groups or in peasant or urban societies. Each of these differs markedly in their resources and abilities. And, different structural patterns on a given level of differentiation may be due to differences among the predominant elites.

Nevertheless, the overall trend refers to levels of organization of differentiated and coacting components and not to the manner in which these are organized within the whole. Just as biological evolution explores myriad possibilities for producing differentiated complex organisms, evolution in the social sector ranges over a wide variety of structural forms in bringing about societies of highly differentiated but coacting systems. Such societies are highly adaptive,

> "but as in all sectors of organization, higher the functional capacity afforded by the more differentiated structure is paid for in the currency of overall stability: the modern technological and bureaucratic society is considerably less stable than the relatively primitive tribal society"(48).

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(48) Ibid., p. 109.

The phenomena has been emphasized in biology section[49] by Prigogine. Thus in social systems and biological systems, adaptation is synonymous with unstabiilty, and functional efficiency in coping with environmental disturbances.

The highly evolved, hence highly unstable but also highly functional social system is the product of an evolutionary process. Boulding likens it to the development of a chick from the egg.

> "The 'egg' is relatively undifferentiated, unorganized. Subsistence economy of small farmers and craftsmen, without large organizations, without much in the way of complex equipment of formal education. The 'chicken' is the developed society with large and complex organizations, complex accumulations of capital in the form of material, skill and educated and informed intelligence and an extensive of labor and differentiation of function"(50).

The difference between two societies is one of degree of organization; the diffusely organized 'egg' society transforms into the differentiatiated and integrated 'chick' society, as the members of the former get jobs in larger organizations, acquire education and skill, and end up in highly differentiated roles.

Although Boulding does not pretend to have solved the problem of measuring levels of societal organization, he does suggest that the gain in the transformation from

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(49) See Biology Section, p. 83.
(50) Boulding, Ecodynamics, A New Theory of Societal Evolution (London: Sage Publications, 1978), pp. 121-141.

a lower to a higher level of organization can be interpreted in terms of the redistribution of entropy. The model based on economy, he argues that consumption means reducing order to disorder for example food to waste, new products to the garbage heap, a typically entropic process. By contrast production is anti-entropic; it imposes a greater degree of order on raw materials of a low level of organization. By virtue of its higher level of production, an evolved economy is more negentropic than an underdeveloped one. However, since society reverses the cycle in the complementary process of consumption, one might have to seek a measure of organization (and therefore, of social evolution) not in the accumulated stock of a society, but in its production-consumption flow(51).

On the contrary, Rifkin and Prigogine argue that, the more complex or differentiated the system, the more energy flow through requires to maintain itself(52). Thus, according to their point of view, the universe approaches entropy death when all the energy is converted into heat of low temperature and the world process comes to an end, sooner or later all living systems appear finally to terminate, from simple organisms to societies, times arrow points ultimately to the dust of entropy. The only case that entropy may decrease(53), if the system develops toward states of

(51) Ibid.
(52) See Biology Section, p. 83.
(53) James Miller, Living Systems (Reprinted from Behavioral Science, Vol. 10, No. 3, 4, July, October 1965).

greater heterogeneity and complexity.

After these pessimistic interpretations I want to end with Rosario M. Levins quote "Confusion evolves into order spontaneously, what God really said was, Let there be chaos"(54).

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(54) Levins quoted in Howard Pattee 'Hierarchy Theory: The Challange of Complex Systems' (New York: George Braziller, 1973),

CONCLUSION

In the introduction, several questions have been posed. The main question was whether we can describe order in social systems or organizations in the same way as we describe it in biological systems or organizations. This main question contains several side questions, including dynamics of both systems, environmental factors, the dilemma of maintenance versus change and the consequences of change or evolution.

The first point emphasized is the wholeness, or systemness. Every component of the whole interacts with each other and properties of the whole emerge from the precise arrangement of the components. In other words, the whole is greater than the sum of its parts.

After describing the importance of systemness, comparison of biological systems with social systems is done by delineating adaptive self-stabilization and adaptive self-organizations. The former implies the properties of self-regulation or homeostatis. While the latter corresponds to evolution.

The framework drawn from the general systems theory, cybernetics, and the second law of thermodynamics aims to explain the issues cited above. However, there is an handicap. Unlike biological systems, direct observation and experimentation is very difficult when social systems are considered. Analogies, isomorphisms and models are appropriately used in disciplines like biology and physics while their application to social problems instantly produces complex operational problems. Although abstract, propositions like feedback, adaptation, self-organization help us to understand social phenomena. Their predictive value, however, is limited.

Throughout the thesis the dynamics of biological and social systems are emphasized in terms of maintenance versus change. Evolution being the evidence of change is described simply by 'mutation-selection'pattern. Mutation-selection pattern operates both in biological and social systems. Only the 'environment' described surrounding the systems is different. Social systems are distinguished by creating their own man-made environment. Adaptations or selection are made through man-made environment. This of being environment is too far from being a 'control' in the sense delineated in biological systems. Cultural evolution may not be easily identified because cultural species are not traceable like biological species. As cultural evolution is an abstract concept, it becomes a matter of judgement to interprete whether a culture evolves or decays.

Like biological evolution the norms of the social system are analyzed under the concepts 'specialization' and 'differentiation'. These concepts imply the ordering process, evolutionary self-organizing trends and processes. Both in biological and social systems complexification is identified with unstability or flexibility and functional capacity. In the cybernetics section(1) it has been emphasized that the evolution acts on 'pattern'. Pattern unlike matter and energy can be created transfered, destroyed and go through isomorphic transformations. This fact can also be interpreted in terms of entropy. Higher level of organization is exemplified by more energy flow or in societies production-consumption flow(2). That is when we 'order' or organize things in our environment, we convert usable energy into unusable energy. The second law thus implies, in the long run, a point at which all energy will be converted into unusable energy. This would of course mean the catastrophic end of life on earth. This state of affairs can only be prevented by evolution, increasing complexity and heterogeneity, the very causes of increasing entropy! This is a serious challenge to the dominanat world view of our time. We have been led into thinking that man is the master of nature and that this is his highest merit to be so. This positivist world view is in contradiction with the implications of the entropy law. The conscious or deleberate design of the world by the human intellect is perhaps not the supreme value. Finally, we came up with an desperate tautology. The more we try to order our

(1) See Cybernetics Section 1.3.
(2) See Biological Systems, p. 82,

environment the greater the disorder created at the overall environment.

On the other hand informal organizations or spontaneous orders, that is undisturbed social systems can not be viewed as natural biological systems. Man is dependent on his cultural environment, which is the product of his own, action and creation.

Two comments can be made with this connection. The first one is that the homeostatic competitive systems are ideal for the verification of informal organizations such as market order. But a small deviation from the homeostatic plateau amplifies the deviation and leads to further discrepancies because of positive feedback.

A second interpretation closes the vicious circle. The steady-state or equilibrial systems that are the systems working on negative feedback mechanism will never be able to evolve since the evolution is a function of positive feedback.

Finally, I want to end with William Morris :

"I pondered all these things and how men fight and lose the battle and the thing they fought for comes about in spite of their defeat and when it comes turns out not to be what they meant and other men have to fight for what they meant under another name'(3)

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(3) William Morris quoted in E.P. Thompson, The Poverty of Theory (London: Merlin Press, 1978).

APPENDIX A

THE GENETIC CODE

The structure and properties of a protein are defined by the sequence (the linear order) of the amino acid residues in the polypeptide. This sequence is itself determined by that of the nucleotides in a segment of DNA strand. The genetic code is the rule which prescribes, given polynucleotide sequence, the corresponding polypeptide sequence..

Since there are twenty amino acids to specify and at the same time only four 'letters' (four nucleotides) in the DNA alphabet, several nucleotides are required for the specifying of each amino acid. The code in fact reads in "triplets': each amino acid is specified by a sequence of three nucleotides.

It is to be noted at once that the translation machinery does not make direct use of DNA nucleotide sequences themselves but of a working copy formed by the 'transcription' of one of the two strands into a one-stranded polynucleotide called 'messenger ribonucleic acid' (messenger RNA). The RNA polynucleotides differ from the DNA nucleotides in a few details of structure, notably the substitution of the base uracil (U) for the base thymine (T). Since messenger RNA serves directly as template for the sequential assembly of the amino acids which are to make up the polypeptide, the code, is here written out in the RNA rather than the DNA alphabet.

The most of the amino acids there exist several different notations in the form of nucleotide 'triplets.' With a four-letter alphabet $4^3 = 64$ three-letter 'words' can be formed; there are however only twenty residues to be specified.

On the other hand three triplets (UAA, UAG, UGA) are labeled 'Nonsense' because they do not designate any amino acid. They do nevertheless play an important role as punctuation signals (at the beginning of end) in reading the nucleotide sequence,

The actual mechanism of translation is complex; numerous macromolecular constituents are involved in it. A familiarity with this mechanism is not indispensable to an understanding of the text. It will be enough to say a few words about the intermediates that hold the key to the translation process. These intermediates are the so-called 'transfer' RNA molecules. These contain:

1. A group which "accepts" amino acids; special enzymes recognize, on the one hand an amino acid, on the other hand a particular transfer RNA, and catalyze the covalent association of the amino acid with the RNA molecule.
2. A sequence complementary to each of the code's triplets which enables each transfer RNA to pair with the corresponding triplet of messenger RNA.

The pairing comes about in association with a constituent, the ribosome, as it were the "workbench" upon which the various components of the mechanism are put together. The messenger RNA is read sequentially, an as yet imperfectly understood mechanism permitting the ribosome to move, triplet by triplet, along the polynucleotide chain. In its turn each triplet pairs on the surface of the ribosome with the corresponding messenger RNA carrying the amino acid specified by that triplet. At each state an enzyme catalyzes the formation of a peptide bond between the RNA-borne amino acid and the preceding amino acid at the end of the already formed polypeptide chain, thus lengthened by one unit. After which the ribosomo moves one triplet further and the process is repeated.

APPENDIX B

NOTE CONCERNING THE SECOND LAW OF THERMODYNAMICS

In the form originally put forward by Clausius in 1850, as a generalization of Carnot's principle), the second law specifies that within an energetically isolated enclosure all differences of temperature must tend to even out spontaneously. Or again - and it comes to the same thing - within such a space, if the temperature is uniform to begin with, no differences of thermal potential can possibly appear in different areas of the whole. Whence the necessity to expend energy in order to cool a refrigerator, for example.

Now, within an insulated and enclosed space at uniform temperature, where no difference of potential remains, no (macroscopic) phenomenon can occur. The system is inert. In this sense we say that the second law specifies the inevitable degradation of energy within an isolated system, such as the universe. "Entropy" is the thermodynamic quantity which measures the extent to which a system's energy is thus degraded. Consequently, according to the second law every phenomenon, whatever it may be, is necessarily accompanied by an increase of entropy within the system where it occurs.

It was the development of the kinetic theory of matter (or statistical mechanics) that brought out the deeper and broader significance of the second law. The "degradation of energy" or the increase of entropy is a statistically predictable consequence of the random movements and collisions of molecules. Take for example two enclosed spaces at different temperatures put into communications with each other. The "hot" (i.e., fast) molecules and the "cold" (slow) molecules will, in the course of their movements, pass from one space into the other, thus eventually and inevitably nullifying the temperature difference between the two enclosures. From this example one sees that the increase of entropy in such a system is linked to an increase of disorder: the fast and the slow molecules, at first separate, are now intermingled, and the total energy of the system will distribute statistically among them all as a result of their collisions; what is more, the two enclosures, at first discernibly different (in temperature) now become equivalent. Before the mixing, work could be accomplished by the system, since it involved a difference of potential between the enclosures. Once statistical equilibrium is achieved within the system, no further macroscopic phenomenon can occur there.

If increased entropy in a system spells out a commensurate increase or disorder within it, an increase or order corresponds to a diminution of entropy or, as it is sometimes phrased, a heightening of negative entropy (or "negentropy"). However, the degree of order in a system is definable (under certain conditions) in another language:

that of information. The order of a system, in such terms, is equal to the quantity of information required for the description of that system. Whence the idea, propounded by Szilard and Léon Brillouion, of a certain equivalence between "information" and "negentropy". An exceedingly fertile idea; but which may give rise to ambiguous generalizations or assimilations. Nevertheless it is legitimate to regard one of the fundamental statements of information theory, namely that the transmission of a message is necessarily accompanied by a certain dissipation of the information it contains, as the theoretical equivalent of the second law of thermodynamics.

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