POST -WAR SYSTEMS ECOLOGY AND ENVIRONMENTALLY - APPROPRIATE APPROACHES IN ARCHITECTURE SINCE 1960'S

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ABSTRACT

POST - WAR SYSTEMS ECOLOGY AND ENVIRONMENTALLY - APPROPRIATE APPROACHES IN ARCHITECTURE SINCE 1960'S

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Environmentally - appropriate architectural works are considered by certain critics as relatively oriented without any theoretical basis other than a technicist perspective. Furthermore, this technicist approach, which puts emphasis on the application of scientific rationality, is supposed as being challenged through an arcadian agenda, which claims the return to pre-industrial values through the revival of the vernacular. In the thesis, it is argued that contrary to the assumptions that the green architecture is highly relativistic depending on the ideological standpoints, it is founded upon a holistic philosophy established on the studies pursued by post-war ecological scientists who followed systems approach. It is claimed that the aforementioned duality between the technicist and the arcadian approaches finds its expression in the contemporary green architecture depending on the philosophical framework provided by the systems approach.

Systems sciences deal with the ways in which elements of a certain whole come together to make up an organization. Its main principle is that a particular element can only be studied with regard to the totality of which it belongs. Ecologists who endow a systems perspective study on the assembly rules through which living and nonliving members of biological systems are organized into groups.

In this thesis, it is put forward that the philosophical outlook and methodology that came along with the systems thinking offers a basis for green architecture. It is provided a historical-analytical survey of the emergence of the systems approach in the architectural discipline since the 60s. It is argued that the 60s appropriation of the systems approach in architecture is still influential in the contemporary green architecture; that today's architects utilize the theories and methods put forward throughout this process of appropriation in their works, alongside the scientific terminology developed by the systems ecologists.

Keywords: Environmentally-Appropriate Architecture, Green Architecture, Systems Ecology, Rationalist, Technicist, Arcadian, Primitivist.

ÖZ

SAVAŞ SONRASI SİSTEMCİ EKOLOJİ VE 1960'LARDAN İTİBAREN MİMARLIKTA ÇEVREYE UYGUN YAKLAŞIMLAR

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Çevreye uygun mimarlık ürünlerinin, bazı eleştirmenler tarafından göreceli yaklaşımlara sahip olduğu ya da tekniğe dayalı yaklaşım dışında herhangi bir teorik temeli bulunmadığı düşünülür. Bunun yanında, bilimsel rasyonalizmi uygulamaya öncelik veren söz konusu tekniğe dayalı yaklaşımın, bölgesel unsurları yeniden canlandırarak endüstri öncesi değerlere dönüşü talep eden kırsal yaklaşım tarafından sorgulandığı varsayılır. Tezde, yeşil mimarlığın ideolojik bakımdan fazlaca göreceli olduğuna dair varsayımların aksine, sistemci yaklaşımı izleyen savaş sonrası çevrebilimcilerinin çalışmalarına dayanan holistik felsefe üzerine kurulduğu tartışılmaktadır. Tekniğe dayalı ve kırsal yaklaşımlar arası sözü geçen ikiliğin günümüz yeşil mimarlığında sistemci yaklaşım aracılığıyla oluşan felsefi çerçeveye bağlı olarak ifade bulduğu iddia edilmektedir.

Sistemci bilimler belirli bir bütüne ait elemanların bir organizasyon oluşturmak amacıyla nasıl biraraya geldiği üzerine araştırma yapar. Temel prensibi, belirli bir elemanın bütünlüğe dayalı olarak incelenmesi gerektiğidir. Sistemci görüşe sahip

çevrebilimciler, biyolojik sistemlerin gruplar oluşturmak üzere organize olan canlı ve cansız üyelerinin biraraya gelme yöntemlerini araştırır.

Bu tezde, sistemci düşünce aracılığıyla oluşan felsefi yaklaşımın ve metodolojinin yeşil mimarlığa bir temel oluşturduğu ileri sürülmektedir. Mimarlık disiplininde sistemci yaklaşımın 60'lardan itibaren ortaya çıkması konusunda tarihsel-çözümsel bir inceleme ortaya konmaktadır. Sistemci yaklaşımın 60'larda mimarlık alanında uygunlaştırmasının günümüz yeşil mimarlığında hala etkili olduğu tartışılmaktadır. Günümüz mimarlarının bu uygunlaştırma sürecinde ortaya konan teorileri ve metodları, sistemci ekolojinin oluşturduğu teknik terimler ile birlikte kullandığı ileri sürülmektedir.

Anahtar Kelimeler: Çevreye Uygun Mimarlık, Yeşil Mimarlık, Sistemci Ekoloji, Akılcılık, Tekniğe Dayalılık, Kırsallık, İlkelcilik.

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INTRODUCTION

1.1. Critical Attempts for Theorizing the Green Architecture

The criticism on green architecture is embedded with the assumption regarding the lack of a coherent outlook that drives environmentally-appropriate works. For instance, the architectural historian John Farmer, ends his book *The Green Shift* with the statement that "there is no conclusive definition of what green means" in architecture.[1] Likewise Colin Porteous, another theoretician on the subject, assumes that "the green architectural spectrum is then a relatively wide and overlapping one"[2], and states: "The solution to the conundrum of sustainable development must lie in accepting the reality of relativity and shifting boundaries."[3] The theoreticians of architecture, Simon Guy and Graham Farmer, write the following on green architectural agenda:

> …making sense of environmental innovation in architecture tends to be a confusing business. Glancing though a myriad of articles, reports and books on the subject of green or sustainable buildings, we find a bewildering array of contrasting building types, employing a great variety of different technologies and design approaches, each justified by a highly diverse set of interpretations of what a sustainable place might represent.[4]

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[1] John Farmer, 1999, *Green Shift: Changing Attitudes in Architecture to the Natural World*, 2nd ed., Oxford: Architectural Press, p. 206.

[2] Colin Porteous, 2002, *The New Eco-Architecture: Alternatives from the Modern Movement,* London and New York: Spon Press, p. 47.

[3] Porteous, p. ix.

[4] Simon Guy and Graham Farmer, 2001, "Reinterpreting Sustainable Architecture: The Place of Technology", in *Journal of Architectural Education*, Vol. 54, p. 140.

Accordingly, the theoretician Suzannah Hagan, in her book *Taking Shape,* points out that green architectural discourse is relative because "green" and "sustainable", which are used as the terms indicating environmental appropriateness in the discipline, harbor diverse viewpoints.[5] She puts that the term "green" indicates the outlook of environmentalist political movements that emerged at the end of 60s, as the result of the public discomfort on post-war environmental deterioration. Basically, those who support green politics envision a society which is based on ethical values, putting environmental concerns ahead of every type of human concern. In this type of society, the right of existence of any living entity is respected. Furthermore, green politicians claim to put a limit to human development, be it in terms of its population, economy, and technology, for the well being of our planet. However, the ideological backgrounds of the green political movements are so disparate from each other that this situation causes the absence of a consensus about how to realize social change. Hence, according to Hagan, to identify environmentally-appropriate architecture with ideologically disparate political bases reinforces the relativity of the green discourse on architecture.

Furthermore, according to her, those who suggest the term "sustainable" on the other hand, are also responsible for "a range of contradictory interpretations"[6]. As information, the term "sustainability" first appeared in a report announced in the UN World Commission on Environment in 1987, which was about the ways of developing a world policy on economic growth by taking environmental concerns into account. The term indicates meeting the needs of current societies without prohibiting the later generations to meet their own needs. Hagan outlines that later it was appropriated to the various disciplines that are concerned with society, politics and environment. As she informs us, while in environmental studies it is used to point to the treatment of ecological environment such a way that it maintains the living conditions of every species on earth, it appeared within social studies as a term to indicate communal developments in which the particular status quo of individuals

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[5] Suzannah Hagan, 2001, *Taking Shape: A New Contract Between Architecture and Nature,* Oxford: Architectural Press, p. 3.
[6] Hagan, p. xiii.

are maintained. Hagan emphasizes that such differentiation in the utilization of the term within the different fields of study rendered the emergence of conflicting approaches about how to appropriate the term in the discipline of architecture. Therefore, while the utilization of the term “green” engendered an ambiguity in ideological perspectives, that of the term “sustainable” resulted in conflicting understandings regarding its appropriation in architecture. Furthermore, the theoretician of environmentalism David Pepper suggests that some radical environmentalist branches censures the use of the term for the reason that it emphasizes economic growth; being always on the side of human priorities, rather than of ecological ones. Accordingly, those which are on the side of leftist green agenda also suspect the integration of the term in environmentalist discourse as well. David Harvey wrote the following:

> Many of the terms used in contemporary environmental debate incorporate capitalistic values without knowing it. Consider, for example, the most favored term in much contemporary discussion – “sustainability”. That term means entirely different things to different people, but it is very hard to be in favor of “unsustainable” practices so the term sticks as positive reinforcement of policies and politics by giving them the aura of being environmentally sensitive… What is then evident is that all debate about ecoscarcity, natural limits, overpopulation, and sustainability is a debate about the preservation of a particular social order rather than a debate about the preservation of nature *per se.* [7]

Returning to the green debate in architecture; despite the lack of a coherent philosophical outlook, many critiques of the subject-matter agree with the idea on the dominancy of scientific and technological paradigms in the discourse. The technology bias was inherited from the social appraisal of industrial rationalism. Farmer wrote the following:

> From the initial investigations certain strands are emerging. Some are visions, some are closer to traditional approaches and some grow out of more standard practices. Within each there are sub-strands and conflicting views….The strongest is undoubtedly still the technological vision… So many of the buildings we have seen in this historical survey have

[7] David Harvey, 1997, *Justice, Nature and the Geography of Difference,* 2nd ed. Oxford and Massachusetts: Blackwell Publishers, p. 148.

> shown that architecture speaks very largely, by association and the critics of hi-tech, see this kind of architecture expressing the technological dominion over the world which has brought about the crisis in the environment… So for us, technology in itself is not to blame for the environmental crisis, it is rather the worldview which sees the earth as a mere stockpile to resources. This we must change and with our attitude to technology. One of the defining features of the machine-age twentieth century has been how separated and sealed off from the environment we have become.[8]

The preeminence of rationalist approach engendered a search among the critiques of architecture for a consistent approach in green design by returning to the modernist origins of architecture. For instance, Colin Porteous wrote in his book that his basic assumption is to locate green architecture to a particular basis through the help of the environmentally-appropriate ideas provided by the architects of the Modern Movement.[9] Likewise, Catherine Slessor emphasizes that the development of green architecture today is based on putting forward technological paradigms in architecture, which was taught us by the modernist ancestors, in a more environmentally-sound way.[10] Moreover, Dean Hawkes, in his book *The Environmental Tradition,* points to the fact that technological implementation provided environmental comfort conditions in the modern buildings; therefore to study on the modern building types might help to advance green architecture of today.[11]

Accordingly, some figures adopt a more critical attitude against this position and point out that it should be social concerns that environmentalist agenda be focused on, rather than the technological issues. They believe that environmental deterioration arise as a result of social patterns of behavior, therefore green architecture should approach environmental subject matter as a social project. The architectural theoretician Richard Ingersoll wrote the following:

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[8] John Farmer, 1999, p. 206.
[9] Porteous, 2002, p. ix.
[10] Catherine Slessor, 2001, *Eco-Tech: Sustainable Architecture and High Technology*, 2nd edition, London: Thames and Hudson, p. 7.
[11] Dean Hawkes, 1996, *The Environmental Tradition,* London: E &FN Spon, pp. 11-25.

> …the question of sustainability in architecture is usually breached through technical rather than historical or social criteria… To be ecological in a merely technical sense will not be enough to be good, but it can no longer be missing from the criteria of goodness. But most of all, for an architecture to be truly sustainable it will necessarily be inscribed in new urban vision or social justice. [12]

Likewise, Guy and Farmer make the following statement concerning the necessity of subsiding towards social matters in green architecture:

> …sustainable buildings are assumed to merely represent differently configured technical structures, with particular pathways of technological innovation viewed as objectively preferable to others. Reflecting the "technocist supremacy" that dominates most environmental research programs, this perspective tends to ignore the essentially social questions implicated in the practice of sustainable architecture… Such "environmental realism" is founded on the notion that "rational science can and will provide the understanding of the environment and the assessment of those measures which are necessary to rectify environmental bads".[13] Further implicit in this model of consensus is a "process of standardization", which means that "particular local conditions" and competing "forms of local knowledge" tend to be ignored.[14]

Similarly, James Wines in his book *Green Architecture,* likewise criticizes the emphasis put to the use of technological imagery, rather to the endowment of an informative basis for social apprehension of green issues.[15] He points out that green expressionism nurtures from the iconography of the International Style, rather than from a particular philosophical perspective that stems from social and cultural interests. According to him, that condition prevents architects from attaining a critical attitude against environmental exploitation, being the major threat to the future of humanity in the contemporary age. He believes the ideological outlook of the early twentieth century does not fit to the current interests of the world societies. Furthermore, he asserts that green architects still use the stylistic imagery of this

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[12] Richard Ingersoll, 1996, "Second Nature: On the Social Bond of Ecology and Architecture", in *Reconstructing Architecture: Critical Discourses and Social Practices,* Minneapolis and London: University of Minnesota Press, pp. 120-152.
[13] Phil Macnaghton and John Urry, in Simon Guy and John Farmer, 2001, p. 140.
[14] Guy and Farmer, 2001, p. 140.
[15] James Wines, 2000, *Green Architecture*, Philip Jodidio (ed.), Köln: Taschen.

period, that in fact belong to rationalist stance, which in turn is responsible for the contemporary environmental destruction. The modern belief in controlling nature via industrial rationality engendered an exploitative attitude towards the environment. He believes that the circulation of modern stylistic imagery, rather than the appropriation of a particular environmentalist approach, sidesteps the contribution of architecture to the mission concerning the endowment of an ethical stance towards nature.

Some critiques try to counterbalance the rationalist bias by searching for the arcadian roots of green architecture. Amongst such figure, John Farmer, believes that the historical background of green architectural thought dates back to the Romantic Movement.[16] Romanticism is an eighteenth century movement of reaction against the values and ideals of the preceding century, the Age of Enlightenment which, with the advent of industrial revolution, displayed a belief in the capacity of human reason via scientific and technological development. Romantics sought for returning to the pre-industrial values of the archaic past, which was not corrupted by social and physical contaminations, against the alienation that the modern ways of living brought forward. They raised against the conditions that separate human values from those of nature; the rationality-driven mind considering natural environment as a source of reification with the aid of technological know-how. They envisioned a society based on community relations and a revival of the spiritual connections with nature as experienced in the primeval times. Farmer points out that the architectural equivalent of the eighteenth century Romantic Movement is the primitive huts that were constructed away from the contaminated cities, or the depictions of modern artifacts in a ruined condition due to its merging with the natural landscape.

According to him, the Romantic idealism was revived once again in the twentieth century after the 60s, with the environmentalist movements. These movements claimed staying away from technicist ideals and attain a more communitarian perspective. They put that humanity needs to improve its social bonds that are lost

[16] Farmer, 1999.

because of the materialistic attitude that is reinforced by the technology-oriented patterns of living. Farmer emphasizes that the architectural equivalent of this Romantic re-appeal in the 60s culture is displayed through the interest to primitive settlements, the application of communal self-built activities to enhance social relations, or minimizing the exploitation of nature via the use of local materials, or via the use of those applied from the nearby surrounding. He writes:

> Whether aligned with the renewal of interest in folk architecture … or with either positive or negative musings about the deep past, many late twentieth century architects gave their buildings similar resonances… Some found links with the deep and archetypally imagined past, sometimes with uplift and optimism, sometimes as metaphorical pits of despair. Others began to reintegrate traditional forms into the language of modern architecture. Others again 'dropped out' and joined the instinctive do-it-yourself trend in making handmade houses – some inspired by pure Rudofsky-like folk sources, others by the urban junk culture of Western cities or Third World shanty towns. In the expediency of their material, the third world shanties come close to the primitive huts of their ancestors in the putting together of what is available, - jerry cans and cheap or waste industrial products instead of the leaves and wood of the forest and the clays and stones of the earth.[17]

Farmer wrote that in the 60s, folk traditions were again referred as in the eighteenth century not this time akin to the Romantic renewal of "what went wrong", but due to "the loss of confidence in the values of the West after a second technologically driven war which had ended with the invention of the ultimately destructive atomic bombs".[18] In this sense, as Farmer puts, while the first revival of folk culture in the Romantic period was because of the dissatisfaction with religious wars, the second revival in the 60s period was because of the dissatisfaction with the technology-driven wars deteriorating the environment.

Similarly, James Wines also supports counterbalancing the rationalist dominancy by highlighting the values of past cultures which display a more sensitive attitude to nature.[19] He thinks that green architects should give up dealing with the Machine-

[17] Farmer, 1999, pp. 14-15.
[18] Farmer, 1999, p.14.
[19] Wines, 2000, pp. 35-64.

Age aesthetics and endow an expressionist attitude based on the visual imagery of the environmentally-sound cultures of the primeval times. However, that should not be in the form of circulation of images emptied of content; architects should attain a philosophical attitude via the cultural patterns of our primeval roots. While doing that, they should take into account the values and interests of contemporary societies and should eschew from falling into any form of nostalgia. His book follows John Farmer's attitude in giving place to contemporary architectural examples that took shape through the utilization of industrial garbage products or local materials, or to the ones that are built in the form of decay as if it is subject to nature's intervention, or that to the ones that are buried under earth as if they were built under survival instinct.

As a result, green architecture seems to be separated into two branches between those who favor the rationalist approach and those who adhere to arcadian idealism. While rationalism highlights technological control of our planet through industrial apparatuses, arcadians seek for setting forth the communal values. They call for an ethical outlook by looking at our primeval roots that displayed dependence on nature. Hagan's following paragraph might be a concluding statement on the splitting of agendas in the green architecture:

> At present, environmental architecture is split between an arcadian minority intent on returning building to a pre-industrial, ideally pre-urban state, and a rationalist majority interested in developing the techniques and technologies of contemporary environmental design, some of which are pre-industrial, most of which are not. The two approaches co-exist within the same ethical framework, share a certain optimism about the possibility of change… From the arcadian minority has come a revival of craft traditions and vernacular techniques for mediating between inside and outside, but it is the rationalist majority who now dominate the field. One has only to look at the proceedings of any conference on environmental architecture in the last twenty years to see the overhelming emphasis on the scientific and quantitative dimensions on the discipline: thermal conductivity of materials, photovoltaic technology, computer simulations, life cycle analysis, and so on…Technically,

> then, this practice is already highly sophisticated, with environmental performance improving constantly. Culturally, it has barely broken the surface of the collective consciousness.[20]

1.2. The Scope of the Thesis: A Theoretical Framework provided by Systems Approach in Green Architecture

As it has been briefly displayed in the aforementioned discussions, both the random circulation of diverse environmentalist viewpoints and the technicist dominancy over the green agenda are issues that are accentuated within the critical discourse on green architecture. Furthermore, certain trials are observed to challenge this technicist dominancy by setting forth the arcadian perspective. The ideological background in the revival of the arcadian perspective is the belief that environmentalism is a social project, rather than the technological one; therefore, it is necessary to reconsider the lost social relations by looking at past values that belong to the times when there was a non-exploitative bond with nature. It is understood that the arcadian perspective is projected to green architecture in diverse spectrums, ranging from vernacular constructions, self-built activities, garbage housing, to bioregionalist settlement projects.

In the thesis, it is argued that contrary to the assumptions that the green architecture is highly relativistic depending on the ideological standpoints, in fact it is founded on a holistic philosophy established on the studies pursued by ecological scientists in the post World War II period. The systems approach in particular, which was developed within the science of ecology, has been highly influential on the philosophy adopted as well as methodologies used by the green architecture. It is claimed that the aforementioned duality between the rationalist/technicist and the arcadian/primitivist approaches, which has been pointed by critics, are evaluated in the contemporary green architecture with regard to the philosophical framework provided by the systems approach. In this sense, both the dominant technicist perspective and the

[20] Hagan, 2001, pp. x-xi.

various positions that find place as a challenge against this technicist dominancy in green architecture are nurtured from the same holistic outlook that is provided by the systems ecology.

There are certain attempts in green architecture both to deal with this duality, and to free the discipline from being relativistic. For instance, Guy and Farmer, in their article, try to put an end to the random distribution of ideas by developing a taxonomy out of six main viewpoints that shapes the green discourse today.[21] According to them, these six different "competing logics" represent diverse cultural outlooks, while overlapping in the green agenda. The logics are developed out of the socio-cultural interpretation of environmental subject-matter, which reinforces the idea that the environmentalist debate is a social, rather than a technological construct. (Fig. 1.1)

Table 1 The six competing logics of sustainable architecture

Logic	Image of Space	Source of Environmental Knowledge	Building Image	Technologies	Idealized Concept of Place
Eco-technic	global context macrophysical	technorational scientific	commercial modern future oriented	integrated energy efficient high-tech intelligent	Integration of global environmental concerns into conventional building design strategies. Urban vision of the compact and dense city.
Eco-centric	fragile macrobiotic	systemic ecology metaphysical holism	polluter parasitic consumer	autonomous renewable recycled intermediate	Harmony with nature through decentralized, autonomous buildings with limited ecological footprints. Ensuring the stability, integrity, and "flourishing" of local and global biodiversity.
Eco-aesthetic	alienating anthropocentric	sensual postmodern science	iconic architectural New Age	pragmatic new nonlinear organic	Universally reconstructed in the light of new ecological knowledge and transforming our consciousness of nature.
Eco-cultural	cultural context regional	phenomenology cultural ecology	authentic harmonious typological	local low-tech commonplace vernacular	Learning to "dwell" through buildings adapted to local and bioregional physical and cultural characteristics.
Eco-medical	polluted hazardous	medical clinical ecology	healthy living caring	passive nontoxic natural tactile	A natural and tactile environment which ensures the health, well-being, and quality of life for individuals.
Eco-social	social context hierarchical	sociology social ecology	democratic home individual	flexible participatory appropriate locally managed	Reconciliation of individual and community in socially cohesive manner through decentralized "organic," nonhierarchical, and participatory communities.

Fig. 1.1. Guy and Farmer's six competing logics in green discourse.

Source: Simon Guy and Graham Farmer, February 2001, "Reinterpreting Sustainable Architecture: The Place of Technology", in *Journal of Architectural Education*, Vol. 54, p. 141.

[21] Guy and Farmer, 2001, pp.140-147.

As the above table suggests, the first "competing logic", according to the writers, are "eco-technic" one, which is according to them the dominant discourse in the green design. The eco-technic logic is represented by the technicist green architects who favor the rationalization of design process through the help of science and technology. Indeed, as mentioned earlier, Suzannah Hagan identifies the technicist architects as the "rationalist majority" of the green architecture. The second "competing logic", according to the writers, is the "eco-centric" one, which is represented by those who endowed a holistic perspective in their designs. According to the writers, systems ecology is the philosophical basis of the eco-centric architects. They approach green design as a moral imperative based on the preservation of equilibrium systems. The writers put that technological implantation is not favored; they refer to vernacular modes of designing or self-built activities by garbage materials. According to them, the "eco-centric" logic is entirely opposed to the "eco-technic" logic in architecture. However, it will be argued in the thesis that the eco-technic agenda abundantly refers to systems ecology, which is indeed contrary to Guy and Farmer's assumptions. Indeed, systems ecology is mainly dominated by a rationalist worldview. It puts emphasis to the preservation of the bioregenerative system of our planet through the help of technology. Hence, the technicist green architects benefit from the systems ecology.

Guy and Farmer's third taxonomy is the "eco-aesthetic" logic. The writers argue that the eco-aesthetic agenda is represented by the architects who set forth the emblematic power of architecture. According to the writers, the philosophical basis of the eco-aesthetic agenda is provided by the contemporary physical sciences.[22] They claim that the green architects also benefit from the Asian religious doctrines in developing their green discourse, which is considered by some critics as the philosophical basis of contemporary physics. Guy and Farmer put that individual expressionism sets forth in the eco-aesthetic branch of green architecture.

[22] Guy and Farmer, p.143.

The fourth taxonomy of the writers is the “eco-cultural” logic, which is represented by the architects who put emphasis on the place identity of a region. The main issue of concern is that the preservation of the cultural diversity is the assurance of the ecological maintenance of a particular region. Accordingly, throughout the Chapter Four of the thesis, it will be displayed that the views of the post-war systems ecologists’ on the necessity of sustaining biodiversity in nature have a certain influence on the integration of the concept of cultural diversity to the green architectural discourse.

The fifth “competing logic”, according to the writers, is the “eco-medical” one, which puts a direct link between the preservation of the healthy condition of an individual and the preservation of nature. According to this view, the disruption of human well-being is the precursor of the disruption of nature, which threatens the ecological well-being of the planet. The writers put that the “eco-medical” logic is projected in architecture by the use of non-toxic materials that are harmless to the environment and to the human health at the same time. Accordingly, with the help of certain theoreticians on the subject, in the Fourth chapter of the thesis, it will be put forward that the research on the impact of the environment on human health began after the integration of systems thinking to the medicinal sciences. Lastly, the sixth “competing logic” that the writers point to is the “eco-social” mentality, which is represented by those who argue that enhancing social communication is the path leading towards ecological sustainability. The writers claim that the representatives of this logic put emphasis on the community interaction as a means to enhance nature appreciation among the public in general.

This thesis puts forward that the philosophical outlook and methodology that came along with the systems thinking offers a basis for green architecture. The Second Chapter focuses on the place of systems approach in the science of ecology. The systems sciences deal with the ways in which elements of a certain totality come together to make up an organization. Its main principle is that a particular element can only be studied with regard to the totality in which it belongs. Therefore, a top-down research and analysis is the method of study in the systems sciences. The biologist Ludwig von Bertalanffy, who set up the theoretical foundations of the systems approach, emphasizes that though systems thinking was inaugurated in the natural sciences, it provides a philosophical outlook to every phenomenon in general; be it biological, economical or cultural.[23]

Systems ecology was developed as a branch of the biological science a decade prior to the Second World War. Systems ecologists tried to decipher the assembly rules through which living and nonliving members of biological systems were organized into groups. Rather than focusing on organisms or species, they dealt with the relationship patterns of bionetworks. The rapid destruction of environment after the war resulted in the acceleration of studies in the systems ecology, thus the embracing of this branch as a scientific discipline within biology. In the post-war era, the public encountered environmental change with discomfort. That condition lead to reactionary responses and thus the inauguration of environmentalist movements and ideologies. The holistic thinking provided alongside the research results on environment made systems ecology an appeal among both these reactionary agendas and individuals that were willing to be informed about the general condition of the ecological environment.

The post-war systems ecologists built their theoretical framework on the idea of a steady-state environment conforming to an equilibrium view, the details of which will be discussed in the Second Chapter. Systems ecology shared the identical faith of every scientific assumption, which is the paradigm shift through the passage of time. The equilibrium view of ecosystem was replaced in the 80s with the theory that an environment can never remain in a stable state; that it is always in flux. The new theory argued that we should seek order in this disequilibrium environment. In the Chapter, the disequilibrium view will be briefly explained.

The suggestion that systems thinking is dominated by the rationalist worldview resulted in the identification of systems ecology with the positivistic scientific

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[23] Ludwig von Bertalanffy, 1968, *General System Theory: Foundations, Development, Applications*, New York: George Braziller, p. 33.

thinking that shaped the rationalist thought since the Enlightenment. However, positivist scientific ideology is considered by the environmentalist thinkers as the philosophical extension of the industrial rationality, which according to them is the reason for the subjugation of nature, thus, for the cause of current environmental problems.[24] However, systems ecology, though being a science itself, is not solely shaped by the rationalist scientific philosophy. It advocates the necessity of technological know-how and scientific research as a cure for deterioration, while at the same time harbors arcadian forms of thinking. Hence, with reference to those who wrote on the science of ecology, it will be argued in the Second Chapter that systems approach integrates arcadian agenda alongside its rationalist outlook.

The Third Chapter provides a historical-analytical survey on the emergence of the systems approach in the architectural discipline. It covers a decade beginning from the end of 60s; the period in which the holistic outlook that came along with the systems sciences was applied to architecture. The influence of systems theory is observed in diverse architectural practices involving with design, construction and theory. In the thesis, it is put forward that systems thinking found a place in the 60s architecture under the dominancy of the rationalist/technicist perspective. Furthermore, it is argued that the rationalist/technicist approach is encountered with arcadian forms of reaction, which indeed provides the historical basis of current reaction against technicist dominion over the green design. In the Chapter, it will be discussed that the rationalist/technicist interpretation of systems approach led to the consideration of the architectural object as a self-sufficient entity operating under a technological construct, while the arcadian perspective, which prevailed as a social activism, was directed towards a variety of tendencies, from primitivism to the revival of the vernacular. The chapter provides clues on how environmentally-conscious thinking was developed via systems approach after the 60s.

[24] For the further information on the critical relationship between the rationalist worldview and environmentalist thinking, see Peter Hay, 2002, in *Main Currents in Western Environmental Thought,* Bloomington and Indianapolis: Indiana University Press.

The Fourth Chapter introduces the reflection of systems approach to the contemporary green architecture. Here, the reader will find clues on how the 60s appropriation of systems approach in architecture shapes today's green architectural discourse. The chapter puts forward how environmentally-conscious works are mostly dominated by the technicist paradigms, which encounters a reaction from those who claim that technicist dominancy curbs the socio-cultural values of localities. Therefore, this chapter is comprised of two sub-sections, based on the views on the ways in which to attain a holistic view. The former sub-section is mainly about current architectural practices in the technicist arena, including those as Sim van der Ryn, Thomas Herzog, Nicholas Grimshaw, Norman Foster, Richard Rogers and Ken Yeang. The leading figure putting emphasis on the technicist side is the architect Ken Yeang, who is well-known for his bioclimatic skyscrapers around the world. In the Fourth Chapter, it will be put forward how Yeang's methodologies on integrating the systems ideas to the architectural design and construction shape the green architectural arena.

Finally, the latter sub-section of the Fourth Chapter introduces the reactions of those who claim that environmental-subject matter should be approached from a social perspective, rather than the technological one. In this section, it will be put forward that the reactions against the technicist dominion over the green design finds its philosophical correspondence from the scientific theory of information, which is part of the theoretical framework of the systems sciences. In the section, it will be understood how the environmentalist reactions are projected in a variety of spectrums in architecture, ranging from vernacular revivals, self-built activities, to anarchic designs reflecting the "revenge of nature" on the building. In the section, the views on the relations between cultural and biological diversity are discussed. The influence of Eastern religious philosophies in systems science and how it reflected on self-built activities and eco-medical approaches in architecture are also discussed. The chapter ends with a brief outlook on the environmentally-conscious works, which project the influence of the paradigm shift in the systems ecology.

CHAPTER 2

THE DEVELOPMENT OF HOLISTIC THINKING ON THE BASIS OF SYSTEMS ECOLOGY

Among ecosystem scientists and systems theoreticians, the chapter gives place mainly to those who are mostly concerned with the future condition of humanity on our planet earth. Basically, it is consisted of five main sections. In the first section, the general shape of equilibrium view in ecosystem ecology will be outlined, with the aid of theoreticians on the subject and mainly with reference from the leading representative of this view, Eugene Odum. The second section outlines another hypothesis set by the systems scientist James Lovelock. Basically, Lovelock's doctrines diverts from the one of Odum's, both in terms of the attitude on ecosystems and in terms of the ideas on the future state of earth. Lovelock's late writings display the shifting state of his ideas, from the equilibrium to disequilibrium view, due to the influence of those who applied the evolutionary doctrines to the systems sciences. Therefore, his views can accustom the reader about the paradigm shifts in the ecosystem science. The third section gives place to the chemist and the systems scientist Ilya Prigogine's ideas on ecological environment, which he put forward with reference to both thermodynamic science and evolutionary ecology. Prigogine was famous for his "far-from-equilibrium" theory, which affected systems ecology. Therefore, the outlining of his views renders the reader to apprehend the disequilibrium vision in the systems ecology.

Consequently, the fourth section introduces the reader another doctrine involved with both equilibrium and disequilibrium vision, which is the theory of ecosystem communication as outlined by the ecosystem ecologists Ramon Margalef and Robert May. The theories on the communication of organisms inside ecosystems have a certain influence on the development of environmentalist ideologies, which try to put forward the social patterns of communication for attaining a responsive approach towards natural environment. Green architectural discourse also benefited from the terminology brought forward by the ecological theory of communication, especially for the development of theories on how to organize social interaction in order to produce environmentally appropriate architecture.

Lastly, the fifth section will introduce the reader with the diverse predictions of the systems scientists about the future condition of our earth, thus the future of humanity. With the help of the theoreticians on this subject, in this section, it is argued that the paradigm shift from equilibrium to disequilibrium view is the reason for the diversity of attitudes towards the environment. Here, the reader will comprehend about the fact that there is not a specific assumption on our planet's future condition; that assumptions divert regarding their scientific approach.

Systems ecology found a place in architecture after the 60s. The appeal to systems view in architecture went in parallel with the public appeal to environmental issues. Architects appropriated the terminology of systems ecology in their practices. Since that time, there is a growing interest in ecological relationships in architecture, due to the ascendancy of environmental deterioration. The following paragraphs will be the first step to understand the response of architecture to the current environmental problems. The general contours of systems ecology will be delineated through particular hypotheses. The postwar efforts in explaining the phenomenon of life will be widely discussed.

2.1. Inside Ecosystem Theory: The Emergence of Economic and Thermodynamic Connotations in the Ecological Sciences

Systems approach began to be carried out in the ecological sciences under the name "New Ecology", which became publicly known after the spread of environmentalism around the world. Ecosystem model affected the ways in which scientists studied the relationship between organism and its environment, thus, have a significant place in ecology. Providing a coherent method of analyzing the natural environment, it marked the beginning of postwar ecological sciences. As Frank Benjamin Golley, the historian of systems ecology informs us; 'ecosystem' concept had been first suggested by the botanist Arthur George Tansley in 1935, in an article which appeared in the scientific journal *Ecology*:

> But the more fundamental conception is, as it seems to me, the whole *system* (in the sense of physics), including not only the organism-complex, but also the whole complex of physical factors forming what we call the environment of the biome-the habitat factors in the widest sense.
> It is the systems so formed which, from the point of view of the ecologist, are the basic units of nature on the face of the earth.
> These ecosystems, as we may call them, are of the most various kinds and sizes. They form one category of the multitudinous physical systems of the universe, which range from the universe as a whole down to the atom.[1]

Golley emphasizes that Tansley's introduction of chemical and physical factors in an environment challenged the conventional assumption about nature operating through the relations of an organism with other organisms.[2] The analysis of nature through interactions of species is the tenet of evolutionary theory, which its basics were developed by the biologist Charles Darwin, and which is still followed by population ecologists as a method of research. Golley claims that unlike the evolutionary view that puts emphasis solely on organic relations; ecosystem approach as put forward by Tansley related the functioning of a community with the relationship between both its biotic (living) and abiotic (non-living) components.

Golley continues to inform that in 1942, the zoologist Raymond Lindeman put Tansley's ecosystem theory into practice.[3] Briefly, Lindeman studied the food and energy cycle of an organic community in the Cedar Bog Lake in Minnesota. He

1 Arthur Tansley in Frank Benjamin Golley, 1993, *A History of the Ecosystem Concept in Ecology,* New Haven and London: Yale University Press, p. 8.
[2] Golley, pp. 8-34.
[3] Golley, pp. 48-94.

grouped organisms into categories -"trophic levels" as ecologists put it- such as "autotrophs" indicating plants or producers and "heteroptrophs" indicating animals or consumers. Then he formulated the interactions between animate and inanimate matter by means of their energy exchange. We learn from Golley that Lindeman's experiments questioned the definition of organic relations in terms of competition. After Lindeman, as Golley puts, organic relations were identified in terms of the mutual aid for energy exchange, rather than struggle for existence. According to Golley, his energy research found out that cooperation may be a social pattern for maintaining life, rather than competition. Golley puts that Lindeman also proved Tansley's views concerning the growth pattern of an ecosystem following the one of an organism.

Another historian of ecology, Robert McIntosh gives information on Lindeman's teacher Evelyn Hutchinson, who believed that Lindeman rendered a dichotomy among ecologists; between those who focused on species' relations -"bio-sociological issues" in Hutchinson's words- and those who "isolated a space and studied the transference of matter and energy across the boundaries of space".[4] As information, the ones that are interested in the species' relations pursue research pertaining to the evolutionary theory, in which nature is envisioned as a selective mechanism with its organisms competing with each other. McIntosh outlines that competition is the basic scheme of evolutionary view and is accepted by population ecologists as the fundamental behavior in community organization.[5] However, the ones studying energy exchange apply ecosystem theory in their practice, with their model of nature shaped by the cooperative action of living and non-living matter.

The science historian Donald Worster explains the theoretical controversy among evolutionary and ecosystem scientists with the difference in the social conjuncture of their period of development.[6] He argues that ecosystem theory took shape in an era

[4] Robert P. McIntosh, 1988, *The Background of Ecology,* 3rd edition, Cambridge: Cambridge University Press, p. 198.
[5] McIntosh, *The Background of Ecology*, p. 178.
[6] Donald Worster, 1995, *Nature's Economy: The History of Ecological Ideas,* Oxford: Oxford University Press, pp.293-295.

of transition in the economic structure, from that belonging to Victorian society to the one of modern industrialization. According to him, evolutionary theory was developed in the Victorian period, in which fierce competition among actors was prerequisite for economic survival. However, ecosystem assumption emerged in the modern social system, with its entrepreneurs cooperating to maintain economic development. For that reason, ecosystem scientists assumed that an ecological environment functioned via workshops for currencies, just like actors of a modern economy. They believed that the biotic cooperation for energy recycling recalled the commercial collaborations for capital exchange. In this sense, in ecosystem view, "cooperation is defined and absorbed by the functions of production and consumption".[7] Therefore, the modern economic society affected the development of ecosystem science; that nature was perceived as a grand economical system in which organisms exchange energy for sustaining the biological environment.

Returning to Golley; he puts that Lindeman's contribution to scientific ecology was not only about his challenging of evolutionary view.[8] According to him, Lindeman also contributed to the dissolution of boundaries between biological and physical sciences. As information, energy issues are the main interest of physics, rather than biology. Despite that fact, he claims that Lindeman's researches on energy flows paved the way to the ecological investigations that are done by applying thermodynamic principles. As a result, ecology began to be concerned with the science of physics, together with the ecosystem theory in the twentieth century. Thermodynamics is the branch of physics dealing with energy transformation within any living or non-living system. The formulation of thermodynamic laws was due to the research on the functioning of steam engines in the nineteenth century. Today, it is accepted that not only mechanical processes, but also living systems are subject to the same thermodynamic principles. In the following paper, thermodynamic principles will be outlined.

[7] Worster, p. 293.
[8] Golley, 1993, pp. 48-94.

2.2. Thermodynamics of Living Systems

As we learn from the chemist Ilya Prigogine and the philosopher Isabelle Stengers, energy exchange in a certain environment is bound up to certain parameters such as pressure, volume, chemical or mechanical composition and temperature, and thermodynamic physics study interrelations of these parameters.[9] Basically, thermodynamics is founded upon two basic principles. The physicist Francis Heylighen informs that the first principle, which is labeled as the 'conservation law', suggests that the total quantity of energy is unchanged in a system; however, the quality changes.[10] Here, potential energy turns into kinetic energy in the form of heat, but the total amount stays the same. The physicists Megan Byrd and Jennifer Renaud explain the peculiarity of potential and kinetic energy.[11] They inform that potential energy is the "energy due to position, or stored energy".[12] According to them, potential energy is at place whenever an object of a certain mass has a position within a field of force. They continue that kinetic energy is "the energy of motion", and writes the following: "Kinetic energy is measured by how much work is done to put an object in motion or to rest."[13] Moreover, Heylighten explains that heat is a kinetic energy developed by "the movement of molecules in a gas or vibration of atoms in a solid".[14]

Consequently, as we learn from Heylighten, the second thermodynamic principle which was labeled as the 'entropy law`, puts forward that the quality of energy irreversibly degrades, while its quantity stays the same, such that the system looses its ability to do work.[15] He informs that the French physicist Sadi Carnot, during his

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[9] Ilya Prigogine and Isabelle Stengers, 1984, *Order out of Chaos,*New York: Bantam Books, p. 119.
[10] Francis Heylighen, 1997, "Entropy and the Laws of Thermodynamics", in *Principia Cybernetica Web*, http://pespmc1.vub.ac.be/ENTRTHER.html, (accessed Sep. 2005).
[11] Megan Byrd and Jennifer Renaud, 2000, *Kinetic and Potential Energy,* http://www.st-agnes.org/~lstinson/webpages/kinpot.htm (accessed Sep. 2005).
[12] Byrd and Renaud.
[13] Byrd and Renaud.
[14] Heylighen, 1997.
[15] Heylighen.

experiments on steam engines in 1824, discovered that some amount of energy producing motion in a mechanical system was degraded in the course of time, causing its malfunction in the end. That indicates energy becoming useless while the total quantity remains unchanged. Heglighten continues that in 1865, the German physicist Rudolf Clausius identified this dissipated useless energy with the constant S. When the amount of dissipated energy, or entropy S reaches to maximum, the system does not work. The system being subject to maximum entropy denotes that it is in thermal equilibrium. Thermal equilibrium points out to the loss of difference in temperature, which is necessary to produce heat. Due to entropy in a system, the temperature difference slightly decreases in time leading to heat death. As a result, energy in a system is always present in terms of quantity; however it always leads to a condition of ineptitude and disorder caused by the uniform temperature distribution. "Potential energy, then, is organized energy; heat is disorganized energy. And maximum disorder is entropy"[16], concludes Heylighen.

According to Prigogine and Stengers, the second principle disputed Newtonian laws indicating the possibility of determining the past or future state of any process through a single formula.[17] Briefly, Newtonian dynamics assumes that gravity is the only force determining the condition of a mechanical or a universal organization. Hence, it is possible to render a process return to its previous gravitational conditions through the utilization of velocity. However, according to them, a thermodynamic system can never return to its initial state even if volume, pressure or temperature is manipulated. Energy disseminates through the course of time, thus, entropy increases. Entropy law puts forward that time is an indicator of irreversible change in determining any mechanical, chemical or biological process. Time always proceeds in one direction.

Moreover, according to Prigogine and Stengers, although entropy increase causes the system's termination, that issue also indicates that it is working. As they put it:

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[16] Heylighen.
[17] Prigogine and Stengers, 1984, pp. 57-61.

"increasing entropy corresponds to the spontaneous evolution of the system".[18] Moreover, as we learn from the physicist Edwin Thall, the notion concerning entropy increase being the indicator for life was confirmed by the German chemist Walther Nernst in the 1920s, through his experiments leading to the formulation of the third law of thermodynamics.[19] Briefly, the third law puts forward that in a matter having atoms aligned in a perfect order, such as crystal lattices, the entropy (S) is 0 at absolute 0 degree Kelvin. Crystals are orderly structures taking shape as the result of physical and chemical processes. The molecular disorder is controlled via temperature in non-living entities as such. However, it is not possible to control entropy of biological systems for their being subject to the continuous exchange of energy and materials in the process of evolution.

The physicist Jack Hokikian explains three types of thermodynamic systems:

> When physicists first formulated the laws of thermodynamics, they considered only isolated systems, which exchange neither energy nor matter with the outside world. This approach works out well for the universe, since the universe includes everything and there can be no "outside world". When energy, but not matter, is exchanged between a system and its surroundings, we have a second type of system-called a closed thermodynamic system. This tends toward a state of equilibrium: the entropy of the system and environment increases toward a maximum value, at which point entropy production ceases. For all practical purposes, Earth and the Sun form a closed thermodynamic system.
>
> Within the thermodynamic family, there is a third and important kind of system-the open system-which can exchange with the environment not only energy but also matter. Life, for example, falls in this category. The entropy formulation can be extended to open systems. Here, we must distinguish two terms in the overall entropy change: The first represents the entropy exchange between system and environment; the second is the entropy produced within the system.[20]

Hence, as Prigogine and Stengers put, "the arrow of time", as they cited in the words of the astrophysicist Sir Arthur Eddington, works not only for mechanical systems,

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[18] Prigogine and Stengers, p. 119.
[19] Edwin Thall, 1998, *Thermodynamics: Who Writes the Laws,* http://mooni.fccj.org/~ethall/thermo/thermo.htm, (accessed Sep. 2005).
[20] Jack Hokikian, 2002, *The Science of Disorder,* Los Angeles: Los Feliz Publishing, p. 63.

but also for living organizations.[21] As they inform us, the isolated system is a type of organization in which the amount of energy is always constant as there is no energy transmission from the environment.[22] The constant energy indicates the possibility of controlling equilibrium conditions inside an isolated system through the manipulation of temperature. Not only isolated systems, but also closed systems are open to manipulation as well. One can control entropy of a closed system if inside temperature is kept constant through heat exchange with the environment. "Equilibrium is the result of competition between energy and entropy", they writes.[23] Although it is possible to avert disorder in an isolated and closed system, there is no means to control entropy in open systems such as biological entities.

The systems theorist Ludwig von Bertalanffy informs that biological organizations are open systems, in which organisms interrelate by continuously exchanging energy and material.[24] He continues that evolution theory considers organisms conforming to their surroundings by modifying their inside structure. This assumption envisions a progressive rise in the complexity of systems in order to correspond to the varying environmental conditions. However, he puts that thermodynamic laws, on the contrary, suggest the inevitable increase of disorder in the system, rather than the progressive rise of complexity. In other words, thermodynamic principles assume diminution in structural intricacies to survive during earthly deprivation. In this picture, an organism cannot develop complex systems in a situation, which there is a constant decrease in the quality of energy and resources. He concludes that there is a contradiction between evolutionary and thermodynamic assumptions.[25] Regarding the subject-matter, Prigogine and Stengers pose the following question: how do

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[21] Prigogine and Stengers, 1984, p. 103.
[22] Prigogine and Stengers, pp. 103-129.
[23] Prigogine and Stengers, p. 126.
[24] Ludwig von Bertalanffy, 1968, *General System Theory, Foundations, Development, Applications*, New York: George Brazilier, p. 41.
[25] For a detailed information on the gap between thermodynamic laws and evolutionary theory, see H. Weber, David J. Depew and James D. Smith (eds.), 1988, *Entropy, Information, and Evolution: New Perspective on Physical and Biological Evolution*, New York and London: The MIT Press.

biological organizations conform to the thermodynamic laws governing isolated and closed systems?[26]

2.3. The Phenomenon of Life in the Entropic Universe

We understood from the above remarks that the explanation of living systems through thermodynamic principles seems to bring forward a conflict in science. The above question can be asked in a different way: how can we explain the phenomenon of life in a system leading to energy dissipation? Hence, one of the founders of quantum mechanics, Erwin Shrödinger, tried to formulate the growth of living systems in terms of thermodynamic laws.[27] The thermodynamic laws suggest that as the energy dissipation of the universe constantly leads to a maximum quantity, entropy always increases and thus has a positive value. Despite that fact, Shrödinger claimed that living entities need to have a mechanism to resist entropy acceleration in order to survive. Through the help of logarithmic equations, he managed to deal with the positive value of entropy and turned it into a negative denomination, though according to some scientists, that situation is no more than playing with numbers.[28] He called this negative state of entropy "negentropy".

In his book, Shrödinger poses the following questions: what is the negentropic system of biological entities? How do they resist entropy acceleration? He claimed that living systems resist death through their metabolism. In this picture, organisms take in food stuff having high energy value and dispel them with a degraded form

[26] Prigogine and Stengers pose the same question in the following expression: "What significance does the evolution of a living being have in the world described by thermodynamics, a world of every-increasing disorder?" in *Order out of Chaos*, p. 129.
[27] The author was informed about Erwin Shrödinger through Eugene Odum's book entitled *Fundamentals of Ecology*, in which Odum referred to one of Shrödinger's formulations deciphering about the maintenance of living conditions in a closed ecological system. See Eugene Odum, 1971, *Fundamentals of Ecology*, London: W. B. Saunders Company, pp. 38-39. The further information on Shrödinger's ideas on life in thermodynamic conditions was compiled from Erwin Shrödinger, 1944, *What is Life and Mind and Matter*, Cambridge University Press.
[28] Hokikian, 2002, *The Science of Disorder,* p. 63.

with the help of their metabolism. According to Shrödinger, exchange of food and energy protects the system from demise though it cannot be protected forever. Metabolism helps organism's "sucking orderliness from its environment" and maintaining "itself on a stationary and fairly low entropy level".[29] In this sense, as Shrödinger informed us, "life seems to be orderly and lawful behavior of matter, not based exclusively on its tendency to go over from order to disorder, but based partly on existing order that is kept up".[30]

The metabolic mechanism is summarized briefly by the physicist and philosopher of science Fritjof Capra, in the following statements:

> To maintain their self-organization living organisms have to remain in a special state that is not easy to describe in conventional terms. The comparison with machines will be helpful. A clockwork, for example, is a relatively isolated system that needs energy to run but does not necessarily need to interact with its environment to keep functioning. Like all isolated systems it will proceed according to the second law of thermodynamics, from order to disorder, until it has reached a state of equilibrium in which all processes –motion, heat exchange, and so on- have come to a standstill. Living organisms function quite differently. They are open systems, which means that they have to maintain a continuous exchange of energy and matter with their environment to stay alive. This exchange involves taking in ordered structures, such as food, breaking them down and using some of their components to maintain or even increase the order of the organism. This process is known as metabolism. It allows the system to remain in a state of nonequilibrium, in which it is always "at work". A high degree of nonequilibrium is absolutely necessary for self-organization; living organisms are open systems that continually operate far from equilibrium.[31]

From above statements, it can be concluded that metabolism indicates a biological process avoiding entropy acceleration for evolution and growth. In that, any living entity can maintain in a low entropic state while accelerating the entropy of its environment. Shrödinger formulated negative entropy to explain the survival of organisms, which are open systems on earth as a closed system. Unlike isolated and

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[29] Shrödinger, 1944, p. 78.
[30] Shrödinger, 1944, p. 73.
[31] Fritjof Capra, 1983, *The Turning Point: Science, Society, and the Rising Culture,* New York: Bantam Books, p. 270.

closed systems subject to equilibrium conditions, living matter exists in the condition of "far-from equilibrium", in Prigogine's words, due to its being continuously in interaction with other materials and organisms. The "far-from-equilibrium" theory will be summarized in the following paragraphs. As a result, it is understood with the aid of Shrödinger's theory; that the negentropy through metabolism helps to capture the endurance of open organizations in an environment leading towards equilibrium.

2.4. Ecology in the Era of Nature Destruction: Ecosystem Approach of Eugene Odum

Indeed, as Prigogine and Stengers put, the clock was the symbol for the mechanical and universal processes subject to Newtonian dynamics in the eighteenth century.[32] According to them, the clock returns to its initial functioning due to the change of its momentum (mass times velocity) regardless of time. They writes the following: "…if the velocities of all points of a system are reversed, the system will go "backward in time". The system would retrace all the states it went through during the previous change".[33] They inform that thermodynamics of the nineteenth century also envisioned universe as a machine as well. That time the cosmological space became a steam engine subject to permanent energy corruption.

As the historian of ecology Donald Worster informs us, in the twentieth century, the catastrophic consequences of the Second World War heralded an increase in the energy dissipation of this engine earth.[34] He continues that the aforementioned condition rendered acknowledgement of ecosystem view in the period after its discovery a decade before. Indeed, as he puts, the ecosystem view deals with questions concerning survival in the disorder of universe. As we learn from Worster, in that period, the subject-matter was the following: How is life possible in an

[32] Prigogine and Stangers, 1984, p. 111.
[33] Prigogine and Stangers, p. 61.
[34] Worster, 1995, p. 342.

environment subject to entropy increase because of technological harm that man made on earth? According to him, this question is thoroughly posed by the systems ecologist Eugene Odum in his book *Fundamentals of Ecology,* published in 1951.[35] Basically, the book provided comprehensive information about the concepts and theories on ecology for the first time.

Worster continues that the disciples of Eugene Odum sufficiently educated the public regarding the disastrous effects of technological products on ecosystems.[36] Such figure he exemplified was the marine biologist Rachel Carson, who gathered her analyses concerning effects of human interference on environment in her book *Silent Spring*. In the book, Carson scientifically proves the negative impact of chemical products used in agriculture to the environment.[37] She writes that her scientific experiments are not for the claim of being against science and technology. According to her, humanity should find appropriate ways for environmental management to be pursued under biological research. She puts that chemicals are the shortest and the most harmful road leading to destruction. She believes that the biological control of growth and reproduction of species might be a longer and a difficult method, but surely it is less harmful. Carson warns that soon man would be a victim of his choices concerning the manipulation of science and technology. The following quotes from the book are widely used by environmental activists:

> We stand now where two roads diverge. But unlike the roads in Robert Frost's familiar poem, they are not equally fair. The road we have been traveling is deceptively easy, a smooth superhighway on which we progress with great speed, but at its end lies disaster. The other fork of the road-the one ‘less traveled by'-offers our last, our only chance to reach a destination that assures the preservation of our earth.[38]

As a result, Carson scientifically proved humans being part of nature, thus being subject to the same effects of destruction influencing ecosystems. The environmental thinker Peter Hay points out that Carson’s book was so influential among the public

[35] Worster, p. 362.
[36] Worster, pp. 342-362.
[37] Rachel Carson, 1962, *The Silent Spring,* Boston: Houghton Mifflin Company.
[38] Carson, p. 8.

that it triggered environmentalist actions a decade later.[39] He writes: "Instead of a seamless development through time, then, the modern environment movement can be quite precisely dated: to the publication in 1962 of Rachel Carson's *Silent Spring*".[40] Accordingly, as Worster puts, her contemporaneous Eugene Odum presented the longest and safer road leading to the survival of the planet, and thus survival of humanity through a comprehensive theory based on ecosystem view.[41] Odum writes in the book *Fundamentals of Ecology* that humans should adapt to the processes of natural ecosystems for negative entropy.[42] Indeed, he was the leading figure in the equilibrium view of ecology, being disputed by evolutionary theorists two decades later. The following paragraphs will briefly introduce Odum's perspective concerning the operation of natural ecosystems and the ways to adapt it to the one of humans.

2.4.1. The Discrepancy between Holistic and Reductionistic Ecology: Odum's Basic Attitude towards Ecosystem Science

In his book, Odum defines ecosystem as follows:

> Any unit that includes all of the organisms (i.e. the community) in a given area interacting with the physical environment so that a flow of energy leads to clearly defined tropic structure, biotic diversity and material cycles (i.e. exchange of materials between living and nonliving parts) within the system is an ecological system or ecosystem.[43]

Odum depicts a picture, in which every organism is interrelated to enable energy recycle in the biological environment. In this sense, an organism in a bionetwork is

[39] The environmental thinker Peter Hay writes the following: "Instead of a seamless development through time, then, the modern environment movement can be quite precisely dated: to the publication in 1962 of Rachel Carson's *Silent Spring*". See Hay, 2002, *Main Currents in Western Environmental Thought* Bloomington and Indianapolis: Indiana University Press, p. 16.
[40] Hay, 2002, p. 16.
[41] Worster, 1995, pp. 362-367.
[42] Odum, 1971, pp. 511-516.
[43] Odum, p.8.

like an organ of a body. According to the historian Benjamin Golley, Odum followed Tansley in his view that members of an ecosystem behave like a single organic unit, thus, an ecosystem is the larger-scaled version of an organism.[44] Moreover, Golley puts that Odum's doctrine in his studies is outlined in the words "the whole is more than sum of the parts", which indicates that making generalizations from the behavior of species does not give any information on the whole ecosystem.[45]

As the historian McIntosh informs us, Odum severely criticized ecological studies putting emphasis on the behavior of species populations, their life histories, and their interrelations.[46] He considered them as "reductionistic". According to McIntosh, Odum believed that reductionistic scientists disintegrate the whole mechanism into smaller parts and "expand the whole knowledge gleaned from parts directly to the whole"[47]. He points out that since Odum distinguished the researches on ecosystem development from those of population ecology, "the distinction between the holistic and reductionistic approaches to ecology was frequently a source of dispute".[48] McIntosh gave place to Odum's following claim in one of his articles, in which he puts that ecosystem science was revolutionary for its giving emphasis on systems view:

> The new ecology is thus a systems ecology-or to put it in another words, the new ecology deals with the structure and function of levels of organization beyond that of the individual and species.[49]

Hence, Odum's emphasis on systems has close alliances with systems theory. The general contours of systems thinking were put forward by the German biologist Ludwig von Bertalanffy in the following:

> A consequence of the existence of general system properties is the appearance of structural similarities or isomorphisms in different fields. There are correspondences in the principles

[44] Golley, 1993, p. 100.
[45] Golley, p. 105.
[46] Odum in McIntosh, 1988, p. 201.
[47] Odum in McIntosh, p. 201.
[48] McIntosh, p. 225.
[49] Odum in McIntosh, p. 200.

> that govern the behavior of entities that are, intrinsically, widely different. To take a simple example, an exponential law of growth applies to certain bacterial cells, to populations of bacteria, of animals and humans, and to the progress of scientific research measured by the number of publications in genetics or science in general. The entities in question, such as bacteria, animals, men, books, etc. are completely different, and so are the casual mechanisms involved. Nevertheless, the mathematical law is the same. Or there are systems of equations describing the competition of animal and plant species in nature. But it appears that the same systems of equations apply in certain fields in physical chemistry and economics as well. This correspondence is due to the fact that the entities concerned can be considered, in certain fields mentioned, and others as well, are concerned with "systems", i.e., complexes of elements standing in interaction.[50]

In his book *General System Theory,* Bertalanffy criticizes the conventional scientific methodology favoring the isolation of the object of study from the mechanism that it belongs to; as, according to him, the part cannot give the total information about the whole organization.[51] Moreover, as seen from the above remark, Bertalanffy identifies the prominent approach of systems science being the determination of relations through mathematical formulas. Accordingly, as McIntosh puts, mathematical relations were first introduced to ecosystem ecology by the zoologist Raymond Lindeman.[52] He refers to Lindeman's teacher Evelyn Hutchinson. As he informs us, Hutchinson claimed that one of the significant attributes of Lindeman was his identification of the complex ecosystem in terms of "pairs of numbers" giving "some hint of an undiscovered type of mathematical treatment of biological communities".[53]

We can conclude the article with reference from the system scientists H. Schugart and R. O'Neill, who summarize the basic attributes of ecosystem research, which followed by Odum as well, in the following, as appeared in McIntosh's book:

> 1. Consideration of ecological phenomena at large spatial, temporal or organizational scales. 2. Introduction of methodologies from other fields traditionally unallied with ecology 3. An

[50] Von Bertalanffy, 1968, p. 32.
[51] Von Bertalanffy, p. 34.
[52] McIntosh, 1988, p. 197.
[53] Hutchinson in McIntosh, p. 197.

> emphasis on mathematical models. 4. An orientation to computers both digital and analog 5. A willingness to formulate hypotheses about the nature of ecosystems.[54]

2.4.2. Negentropy of Bionetwork: The Bioregionalist Impulses of Odum

In the above article, we learned about Shrödinger's views on the survival of a single organism despite entropy. In his book, Odum refers to Lindeman and mentions that ecosystem displays a collective behavior for survival.[55] In other words, not only a single organism, but also ecosystems work together to resist decay. There is a negentropic system inherent in ecosystems, as well as in organisms:

> Organisms, ecosystems and the entire biosphere possess the essential thermodynamic characteristic of being able to create and maintain a high state of internal order, or a condition of low entropy (a measure of disorder or the amount of unavailable energy in a system). Low entropy is achieved by a continual dissipation of energy of high utility (light or food, for example) to energy of low utility (heat, for example). In the ecosystem, "order" in terms of a complex biomass structure is maintained by the total community respiration which continually "pumps out disorder". [56]

As a result, it is understood that the members of an ecosystem collectively operate their metabolic functioning, such as community respiration, or community nutrition etc. In this picture, metabolism is the process of maintaining internal order for persistence. Hence, that idea inspires environmentalist ideologies a decade later, in studying the communal patterns of individuals in a social setting for an environmentally-benign future. Indeed, Odum not only got help from his colleague Lindeman, as Worster puts, he benefited from his sociologist father Howard Odum in setting-up the collective practice of organisms.[57] We learn from the historian Robert

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[54] H. Shugart and R. O'Neill in McIntosh, p. 229.
[55] Odum, 1971, p. 9.
[56] Odum, p. 37.
[57] As information, Worster' hypothesis in his book is that the ecological scientists develop their theories with regard to the social setting of the era in which the theories are produced; hence, this condition is one of the case.

C. Bannister that the father Odum is famous for his studies on the collective practices of society in giving value to their local surroundings:

> The antithesis of sectionalism, regionalism to Odum meant cooperation and coordination among the nation's major areas, delimited by geography, history, and culture. His goal was unity through diversity. More than a social program, regionalism was a conceptual framework for synthesizing the social sciences and even the humanities and natural sciences. Odum saw the world, one of his students noted, "in larger units, [and] deeper patterns than he could communicate or we could understand."[58]

Moreover, not only the son Eugene Odum, but also environmentalists in general benefited from the ideas of the father Odum as well. For instance, the historian of environmentalism Peter Hay puts that "bioregionalism" in environmentalist thinking is founded upon Howard Odum's aforementioned perspective.[59] Accordingly, another historian of environmentalism David Pepper explains "bioregionalism" in environmentalist ideology in the following:

> The principles of bioregionalism is liberating the self, reducing the importance of impersonal market forces and bureaucracies, opening up local political and economic opportunities, enjoying communitarian values of cooperation, participation, reciprocity and confraternity, and having roots. This is all in order to develop the region's potential towards self-reliance and to develop a sense of place in people who live there- the latter involves learning about folklore and history and the technologies that 'traditional' people had.[60]

Howard Odum's biographer Robert C. Bannister puts that after his studies on regionalism, the father Odum continues to work on "the destruction of traditional community through technology and the resulting intellectualism, specialization, and centralization of the modern state".[61] Indeed, the critical distance put to the idea of specialization exists in systems sciences as well. As the biologist and systems theoretician Bertalanffy puts, specialization is one of the reasons averting one from

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[58] The information was compiled from Robert C Bannister, 1977, the Dictionary of American Biography, Supplement 5 (c), in American Council of Learned Societies http://www.swarthmore.edu/SocSci/rbannis1/pubs/Odum.htm (accessed Sep. 2005)
[59] Hay, 2002, p. 285.
[60] David Pepper, 1996, *Modern Environmentalism,* London and New York: Routledge, p. 307.
[61] Bannister, 1977.

holistic thinking and apprehending the general picture of things.[62] We will see in the subsequent chapter that architects who are interested in the systems sciences endowed with the same frame of thinking as well; that the architect and the systems scientist Buckminster Fuller keeps his distance from those involved with specialization.

To summarize; we learn from above remarks that Odum in a way theorized by benefiting from Lindeman's studies on how organisms work together for energy exchange and Shrödinger's studies on how organisms resist entropy. Furthermore, he took the general idea from his father's studies on the regionalist instincts of human society; how they communicate together to give values to their locality. The above remarks display that even the holistic perspective of Eugene Odum seems to be inherited from the father.

2.4.3. The Principles for a Stable Environment

In his book, Shrödinger summarizes his doctrine of negentropy with the following statement, indicating that although every practice requiring energy flow increases the entropy of the universe, it reveals the phenomenon of life:

> What then is that precious something contained in our food which keeps us from death? That is easily answered. Every process, event, happening-call it what you will; in a word, everything that is going on in Nature means an increase of the entropy of the part of the world where it is going on. Thus a living organism continually increases its entropy-or as, you may say produces positive entropy-and thus tends to approach the dangerous state of maximum entropy, which is death. It can only keep aloof from it, i.e, alive, by continually drawing from its environment negative entropy. What an organism feeds upon is negative entropy. Or, put it less paradoxically, the essential thing in metabolism is that the organism succeeds in freeing itself from all the entropy it cannot help producing while alive. [63]

[62] Bertalanffy, 1968, p. 206.
[63] Shrödinger, 1944, p. 76.

We learn from him that while the process of energy and material exchange decreases the possibility of death, it increases the entropy of its environment. The philosopher Capra, in his book *The Turning Point*, poses the following question regarding the subject-matter: What happens when organism or ecosystem is subject to pressures from its environment such as climatic changes, which might destroy its internal order?[64] Odum gives a scientific explanation to this question, and informs us that ecosystems have a mechanism of resistance against external forces in order to continue their metabolic functioning:

> Ecosystems are capable of self-maintenance and self-regulation as are their component populations and organisms. Thus, *cybernetics* (fr. *Kybernetes* = pilot or governor), the science of controls, has important applications in ecology especially since man increasingly tends to disrupt natural controls or attempts to substitute artificial mechanisms for natural ones. *Homeostasis* (*homeo*=same; *stasis*=standing) is the term generally applied to the tendency for biological systems to resist change and to remain in a state of equilibrium. [65]

In the above explanation, Odum points out that, ecosystems resist external forces and remain in an equilibrium state by the help of their homeostatic mechanism. Hence, homeostasis is one of the indicators of the equilibrium picture. We can understand here that while metabolism sustains energy flows in an organic entity, homeostasis sustains metabolism. Energy exchange processes increase entropy; and entropy increase means that the system is working. Homeostasis is needed to resist to the entropy of the environment and to maintain the internal structure.

Furthermore, Odum informs us how this homeostatic mechanism works in a living system.[66] For that, he explains the functioning of a “thermostat or household heat control apparatus”. According to him, a thermostat is a system having homeostatic control. Briefly, as Odum explains us, it has an effector receiving energy from a source, such as fuel, and a sensor that controls increase of heat with regard to the

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[64] Capra, 1983, p. 272.
[65] Odum, 1971, pp. 33-34.
[66] Odum, p. 34.

room temperature. Here, he indicated the room temperature as "the controlled quantity"[67]. He puts that for a mechanical system to work, the temperature inside the system should be counterbalanced through the energy received by means of the controlled quantity. He informs that the neutralization of input energy through output heat is called negative feedback. Here, if the sensor does not work, the temperature inside the system increases due to relentless heat gain. The increase in the amount of heat indicates that the system has positive feedback. Odum puts that the uncontrolled heat increase damages the system. (Fig. 2.1.)

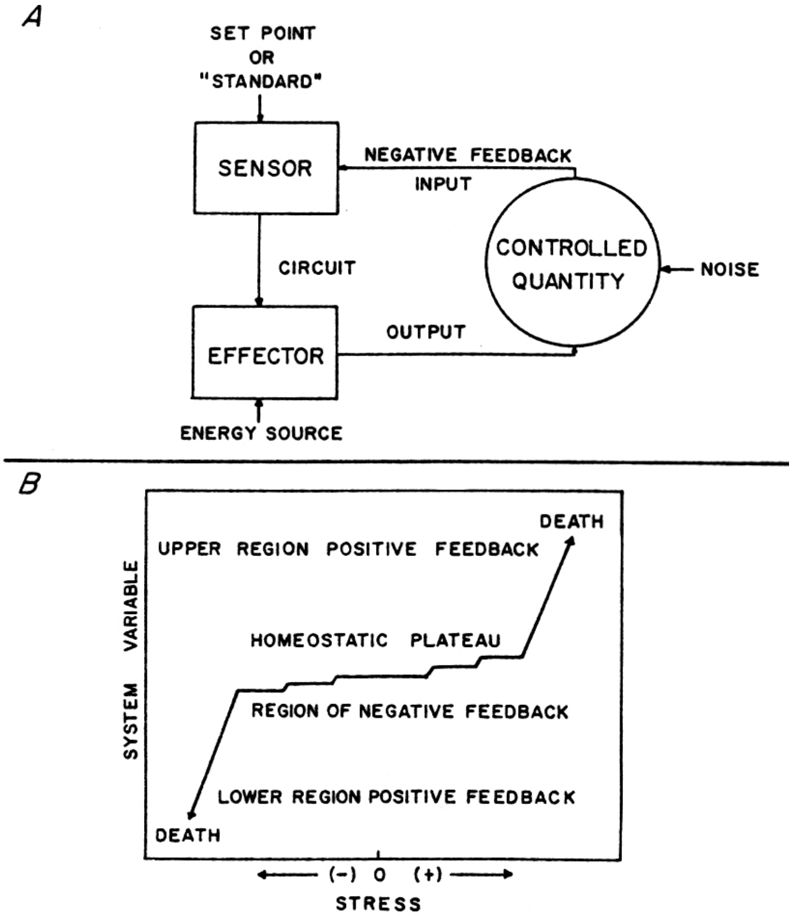

Fig. 2.1. Odum's diagram displaying the operation and feedback of a thermostat. Source: Eugene Odum, 1971, *Fundamentals of Ecology*, London: W. B. Saunders Company, p. 34.

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[67] Odum, p. 34.

Odum's above assumption of thermostatic ecosystems indicates the existence of mechanical metaphors in biological sciences. Indeed, it was mentioned earlier that thermodynamic principles, being the interest of ecosystem science, were introduced via observing mechanical engines. The nineteenth century thermodynamics envisioned earth working like a steam engine. As a result, while the engine is the metaphor for isolated earth, the thermostat is the one for a biotic structure. The Spanish ecosystem ecologist Ramon Margalef writes the following in his book *Perspectives in Ecological Theory:* "The ecosystem is analogized to a machine- this is the input and that is the output. But a new and important notion is that the working of the machine is related to the energy passing through it".[68] In the following, Odum outlines the functioning of a thermostatic mechanism in ecosystems:

> As in the turbodistat, some populations are regulated by density, which "feeds back" by way of behavioral mechanisms to reduce or increase the reproductive rate (the "effector") and thus maintain the population size (the "controlled quantity") within set limits. …control mechanisms operating at the ecosystem level include those which regulate the storage and release of nutrients and the production and decomposition of organic substances. The interplay of material cycles and energy flows in large ecosystems generates a self-correcting homeostasis with no outside control or set-point required. [69]

In this statement, he puts that the negative feedback mechanisms of ecosystems controls the general rate of reproduction, energy flow or consumption of food etc, in an ecosystem. As a result, living systems are envisaged like a machine in ecosystem ecology. Moreover, homeostasis is considered as a necessary phenomenon for conserving the integrity of biological systems, despite external influences forcing alteration. In this sense, the organizational structure inside the ecosystem is preserved, so that organisms regularly take in order and eliminate disorder.[70] As Margalef puts:

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[68] Ramon Margalef, 1968, *Perspectives in Ecological Theory,* Chicago and London: The University of Chicago Press, p. 49.
[69] Odum, 1971, p. 35.
[70] The author became acquainted with Ramon Margalef's claims of the conservative capacity of biological systems from the book written by the Spanish architect Luiz Fernandez Galiano. See

> Thus, conservatism seems to be a law of nature, and systems endowed with the highest stability of form -no new properties being added that are not accounted for- may be rightly considered the best channels of information.[71]

In the *Fundamentals* book, Odum writes that a machine ecosystem regulates energy flows to remain in a stable state:

> …any natural enclosed system with energy flowing through it, whether the earth itself or a smaller unit, such as a lake, tends to change until a stable adjustment, with self-regulating mechanisms, is developed.[72]

From his remarks, we understand that Odum considers our biosphere and ecosystems as closed units. Furthermore, he refers to one of Shrödinger's formulas that determine the stability of ecosystems in terms of energy quantities.[73] In that formula, stability is dependent upon a ratio of energy flows per unit biomass, which is the total weight of a single organic matter. Moreover, Margalef states that this stability ratio is lower in an efficient organization and higher in an inefficient organization.[74] Here, efficient ecosystem means that organisms require fewer amount of energy; therefore the ratio is low. Whereas, inefficiency is the indicator of organisms needing extra energy to maintain their ecosystems; therefore the ratio is high. The maximum flow of energy in an ecosystem means that entropy production is to the highest degree. We learned from Odum that maximum entropy is the indicator of positive feedback. Therefore, the maximum consumption of energy and food indicates acceleration of malfunction, hence, death.

Furthermore, in his book, Margalef puts that there is a one-to-one correspondence between stability and diversity of an ecosystem.[75] Diverse environment indicates that

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Galiano, 2000, *Fire and Memory: On Architecture and Energy*. Massachusetts: The MIT Press, pp. 62-67.

[71] Margalef, 1968, p. 3.
[72] Odum, 1971, p. 38.
[73] Odum, pp. 38-39.
[74] Margalef, 1968, p. 21.
[75] Margalef,, p. 21.

ecosystem works efficiently. Efficient ecosystem indicates that it is stable. In a stable system, minimum entropy is produced for diverse species to survive. Accordingly, Odum, in his book, repeatedly emphasized the importance of conserving the biological diversity on earth.[76] According to him, if humanity continues to threaten biodiversity, ecosystems loose their negative feedback mechanism. They cease to function like a thermostat. The malfunctioning of ecosystems refers to collapse of machine earth. As a result, biodiversity is the second indicator of equilibrium picture, while the first indicator was homeostasis.

Accordingly, Odum informs about another indicator of equilibrium picture; which is evolutionary adaptation:

> We shall also have many occasions to note that really good homeostatic control comes only after a period of evolutionary adjustment. New ecosystems (such as a new type of agriculture) or new host-parasite assemblages tend to oscillate more violently and to be less able to resist outside perturbation as compared with mature systems in which the components have had a chance to make mutual adjustments to each other. [77]

We understand from here that ecosystems, which have adjusted to their surroundings via evolutionary development, are more successful in regulating energy flows and in producing minimum entropy.

In this article, the principles for a stable development in ecosystem are briefly summarized; which is homeostasis, biodiversity and evolutionary adaptation. Accordingly, Worster puts in his book *Nature's Economy* that ecosystem scientists' stability picture was developed with the help of the economic system of that period.[78] He writes that the division of labor among individuals was introduced to maintain economic stability at that era. The proper business was considered as the one in which each laborer was linked with others through a specific task. We learn from Margalef that in a stable ecosystem, organic members are linked with each other for

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[76] Odum, 1971, pp. 510-511.
[77] Odum, p. 35.
[78] Worster, 1995, p. 315.

the task of sustaining minimum flow of energy and food.[79] Indeed, Margalef's assumption resembles Worster's picture of a stable economic system.

2.4.4. Spaceship Economy of Human Set-Up

As stated in above paragraphs, Odum informs that the increase of temperature in a system indicates that the machine has positive feedback, which leads to malfunction. In the *Fundamentals book*, he added that living systems also might suffer from positive feedback that can occur in the case of uncontrolled growth.[80] However, according to him, that situation occurs rarely indeed, as living systems generally have homeostatic control, except human organizations. He writes:

> It is man the geological agent, not so much as man the animal, that is too much under the influence of positive feedback, and therefore, must be subjected to negative feedback.[81]

According to Odum, the tendency of human systems to positive feedback is the indicator that humans have not learned ways for long time habitation on our planet yet.[82] Odum warns that humans should not divert themselves from living systems; both belong to the earthly system in general.[83] He puts that there is not a clear distinction between human and natural systems. Regarding this thesis, in his book, he defines five types of closed ecosystems as objects of study: a pond, a watershed unit, a meadow, a microecosystem and a spacecraft.[84] We understand from here that he includes a technological unit as part of organic network. He finds no disparity between a spacecraft and a natural ecosystem. Indeed, he puts in his book that organisms of an ecosystem resemble astronauts of a spaceship; they exchange limited

[79] Margalef, 1968, p. 21.
[80] Odum, 1971, p. 36.
[81] Odum, p. 36.
[82] Odum, p. 498.
[83] Odum, p. 12.
[84] Odum, pp. 22-23.

amount of energy and food for long time survival in a closed unit.[85] Furthermore, he claims that a spaceship is the smaller version of a city, being the locus of human ecosystem. Both are the parts of human systems and both are subject to the same environmental problems such as:

> detection and control of air and water pollution, adequate quantity and nutritional quality of food, what to do with accumulated toxic wastes and garbage, and the social problems created by reduced living space"[86]

Odum believes that the growing descent in the wellbeing of our planet is because of the lack of information about space habitation:

> The fact that we are not now able to engineer a completely closed ecosystem that would be reliable for a long existence in space is striking evidence of our ignorance of, contempt for, and lack of interest in the study of vital balances that keep our own biosphere operational.[87]

In his book, Odum gives prescriptions on how to enhance our negative feedback systems. [88] According to Odum, every human being has to envisage himself/herself as a space traveler; he/she has to develop "a spaceship economy in which emphasis is placed on the quality of the capital stock and human resources rather than on rates of production and consumption" for planetary well-being.[89] He points out that the place in which humans have to practice economic means of surviving on the planet is the spaceship. Hence, in his opinion, understanding of a spacecraft mechanism helps man both to develop negative feedback systems and to utilize minimum amount of energy for utmost means of survival. (Fig. 2.2.)

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[85] Odum, p. 498.
[86] Odum, p. 498.
[87] Odum, p. 498.
[88] Odum, pp. 510-516.
[89] Odum, p.516.

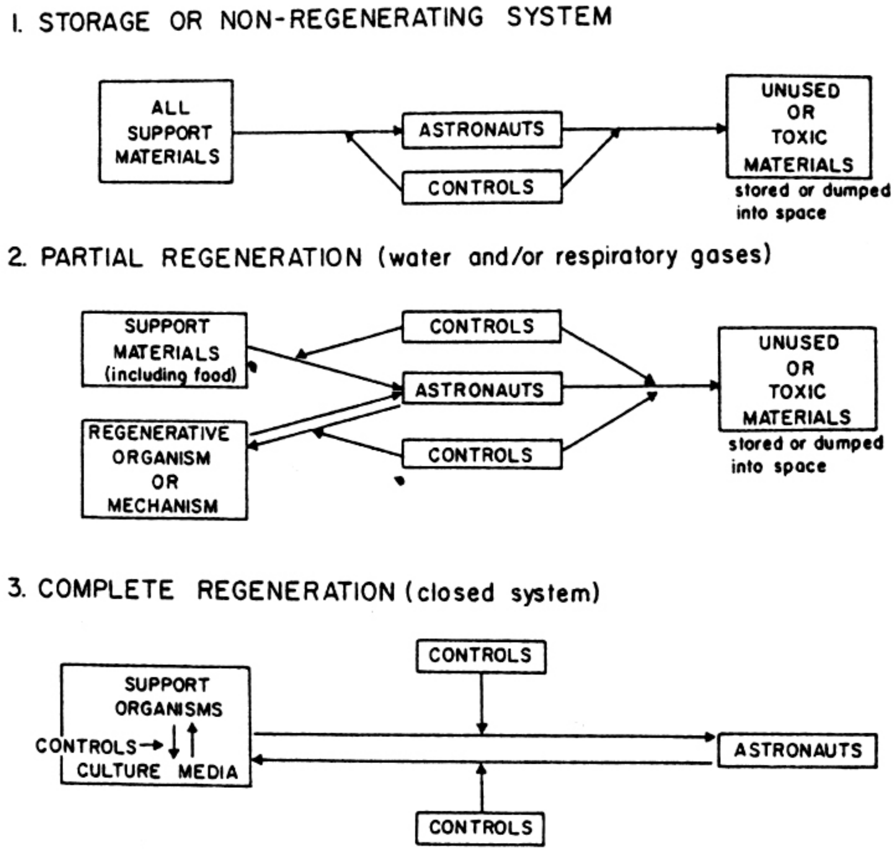

Fig.2.2 Odum's diagram of spaceship economy.
Source: Eugene Odum, 1971, *Fundamentals of Ecology*, London: W. B. Saunders Company, p. 499.

Accordingly, Worster puts that Odum's frequent use of spacecraft ecology was because of the inauguration of space travels in that era:

> On the occasion of the first Earth Day the public's attention was momentarily diverted from the crisis of the environment to the crisis of the spacecraft Apollo 13. On its way home from the moon, the craft had gone awry when an explosion occurred aboard, threatening the life of the crew. After many tense hours, with millions listening in, they had managed to get inside their lunar module and abandon the ship. Eugene Odum used the incident years afterward as a model of our environmental situation on "Spaceship Earth". Here too, our life-support system was being destroyed, though in this case we had no handy little module to jump into and rocket away. We had to stay aboard and try to repair the craft. He noted that the earth,

unlike Apollo 13, was a "bioregenerative system," that is, it had its own powers of recuperation, unlike a machine. Nonetheless, our predicament was even direr than the astronauts', for we had neither the possibility of escape nor the knowledge adequate to repair the vessel. [90]

Odum concluded his book with remarks on the maintenance of earth spaceship. Basically, he compiled his suggestions under various headlines, which are, birth control, urban land use planning, enhancement of appropriate taxation systems to control population rate, augmentation of world-wide economy for resource management etc. His suggestions under the practices of management and control are indicators that the managerial attitude was dominant in ecosystem science since its first years of development. He believed that like ecological systems being governed by cybernetic mechanisms, human organizations should also have a control mechanism managing natural resources. (Fig.2.3.)

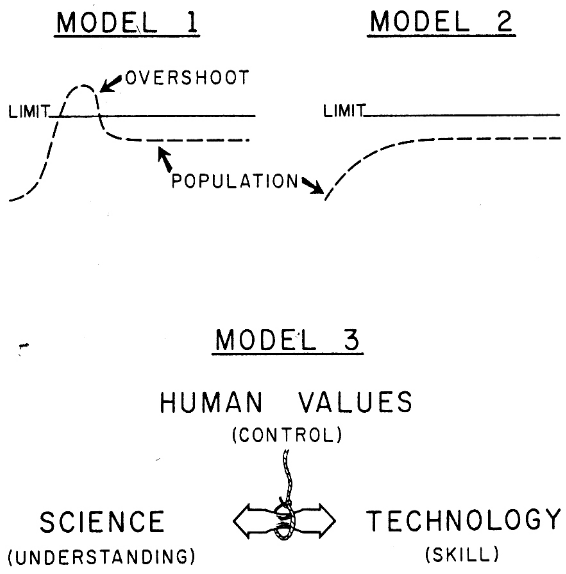

Fig. 2.3. Odum's diagram displaying human cybernetics.
Source: Source: Eugene Odum, 1971, *Fundamentals of Ecology*, London: W. B. Saunders Company, p. 515.

[90] Worster, 1995, p. 369.

In the above diagram, we understand that Odum considers science and technology as the main agents leading to human cybernetics. He puts in his book that humans seem to construct economic systems according to cybernetics; that international economic organizations deal with the controlled flow of financial supplies between countries. He puts that social and political systems should conform to this political structure as well. For instance, he requested a political reconstruction in order to deal with integrating urban and rural space. His last suggestion was coined under the "town and country interaction" headline, which he mentioned about the need for:

> …general realization that the city depends on green countryside for air, water and food and the country depends on the city for economic resources, so that the present political confrontation between urban and rural populations can be replaced by a total political concern for the urban-rural complex as one system.[91]

Accordingly, the historian Donald Worster informs that Odum's favoring of environmental management has parallels with the economical means of valuing nature in the modern era:

> One further characteristic of modern economics will become especially relevant here: the development of a managerial ethos. It has come to be a widespread assumption that neither man nor nature can long survive without direction and control by trained managers. This faith in management is one of the more significant products of technological elaboration: eventually every specialty begins to appear too complex for lay understanding. Moreover, the compulsion to improve output, to reorganize the world for the sake of ever higher economic achievements, creates a corollary reliance on social planning, personal management, and resource engineering. Letting things alone, it is feared, will lead to stagnation, poverty, idleness, chaos. The technological imperative is that things can always be done better-and must be. That is the only, and the sufficient, rationale for our increasingly managed world.[92]

The theoretician of ecology, Robert P. McIntosh finds the relations of ecosystem ecology with economic reasoning "reasonable enough given the often stated origins

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[91] Odum, 1971, p. 516.
[92] Worster, 1995, p. 294.

of ecology and economics from the same Greek root meaning 'house'."[93] He mentions about the scientist H. G. Wells saying that "economics is a branch of ecology".[94] Indeed, the following statements from Odum confirm McIntosh in this sense:

> It is interesting to note that the words "economics" and "ecology" have the same root, *oikos*, which refers to "house". It can be said that economic deals with financial housekeeping and ecology deals with environmental housekeeping. While energy can be thought of as the "currency" of ecology, energy and money are not the same because they flow in opposite directions and money circulates while energy does not.

Odum compared economic setting with ecological one by referring to their etymological origins. Like economics favoring the most effective capital circulation in a human system, ecosystem ecology favored the efficient circulation of resources for maximum means of growth. Economy provided the grounds for ecological scientists to make associations between the natural and the social worlds. It offered an outlook to apply the results of scientific data to human ecology. Hence, the ecologist is a philosopher combining the natural and the social worlds. In an article, Odum makes the following statement:

> …during the environmental awareness decade, 1968 to 1981, a school of ecosystem ecology emerged that considers ecology to be not just a subdivision of biology, but a new discipline that integrates biological, physical and social science aspects of man-in-nature interdependence.[95]

Accordingly, we learned that Odum reserved the latest part of his book to the combination of the natural and the social. Therefore, his spaceship construction has sociological and psychological dimensions, aside from its scientific and technological aspects. He emphasizes that the secret of mending our planet for the "continual survival on earth spaceship"[96] will be revealed when humanity discovers

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[93] McIntosh, 1988, p. 303.
[94] McIntosh, p. 303.
[95] Odum in Robert McIntosh, p. 202.
[96] Odum, 1971, p. 498.

long term existence in an artificial spacecraft. According to him, ecologists should focus on managing resources for long-time habitation. After that, as he puts, repairing our sick planet will become as easy as "mending the radio or the family car"[97]. He assumed that humanity may not counterbalance the damage that he/she has done unless he/she put the aforementioned issues into practice.

The environmentalist thinker Peter Hay puts that holism, being a prominent model of thinking in ecosystem science, brought socio-economical currents closer to the focus of scientific research, thus located ecology into a unique position among other "hard" sciences.[98] The philosopher E.C. Lindeman, as McIntosh quotes in his book, conceives ecologists as philosophers that "acquired the habit of dealing with wholes as well as fractions" and ecology "as the middle ground where the physical and biological sciences leave off and the social sciences begin".[99] Holistic thinking is reflected to the method of ecosystem research in two ways. First, it rendered scientists to analyze a specific landscape by considering every living and non-living element. [100] Second, it gave way to the involvement of figures from various disciplines to evaluate the results of scientific research.[101]

However, as the historian of ecosystem science F.B. Golley puts, the need for interdisciplinarity caused the diminishing role of ecosystem ecology within other branches of biology.[102] He puts that the interdisciplinary research required the need for a considerable capital and that issue put the students of biology into a difficult situation. As a result, as Golley informs us, 70s marked a shift of interest to the

[97] Odum, p. 36.
[98] Pepper, 1996, pp. 240-241.
[99] Robert P. McIntosh, p. 304.
[100] As mentioned earlier, ecosystem approach focused on the relationship between biotic and abiotic entities rather than solely examining social relations between living members. See Arthur Tansley's remarks in Golley, 1993, *A History of the Ecosystem Concept in Ecology,* New Haven and London: Yale University Press, p. 8.
[101] Frank Benjamin Golley emphasizes that studying the whole ecosystem required the involvement of various scientists making investigation harder to pursue due to financial reasons. See Golley, *A History of the Ecosystem Concept in Ecology,* 1993, New Haven and London: Yale University Press, pp. 1-8.
[102] Golley, p. 6.

topics of evolutionary biology from that of ecosystem science.[103] He points out that evolutionary biology enabled individual research and the space and cost needed for research was not as high as the ones required for ecosystem ecology. In this sense, the simplicity of "dealing with fractions" was the challenge of evolutionary to ecosystem science. In the subsequent parts of the thesis, the confrontation of evolutionary ecology to ecosystem theory will be outlined.

2.5. From Ecosystems to Superorganisms: The Gaia Hypothesis of James Lovelock

Odum believed that human systems, due to their lack of homeostatic control mechanisms, destroy the bioregenerative mechanism of our planet:

> Nature, with our intelligent help, can cope with man's physiological needs and wastes, but she has no homeostatic mechanisms to cope with bulldozers, concrete, and the kind of agroindustrial air, water and soil pollution that will be hard to contain as long as the human population itself remains out of control.[104]

The historian of ecology Donald Worster writes that, through his assumptions on our earthly system, Odum "mixed mechanistic and organic metaphors to a confusing degree."[105] He continues with the following: "Was the Earth alive or dead? Sick like an organism or malfunctioning like a machine? Did it need a physician or an engineer? Eugene Odum tried to have it both ways."[106] However, the NASA scientist James Lovelock, as the result of subsequent experiments that he made at the end of 60s, claimed that earth is a living entity never loosing its power to heal itself; whether for the benefit of humanity or not.[107] He considered earth as the greatest ecosystem subject to self-regulation and self-maintenance. He believed that like an

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[103] Golley, p. 6.
[104] Odum, 1971, p. 36.
[105] Worster, 1995, p. 370.
[106] Worster, p. 370.
[107] James Lovelock, 1995, *The Ages of GAIA*, 2nd ed., Oxford: Oxford University Press.

organism fighting against entropy and decay, earth pumps out disorder, too, though that fighting act might result in pumping out humanity also. He explained earthly activities in a comprehensive theory that he named “Gaia”, after the goddess of earth in Greek mythology.[108] In his book, Lovelock defined Gaia as follows:

> Gaia is best thought of as a superorganism. These are bounded systems made up partly from living organisms and partly from nonliving structural material. A bee’s nest is a superorganism and like the superorganism Gaia, it has the capacity to regulate its temperature.
> The name of the superorganism, Gaia, is not a synonym for the biosphere. The biosphere is defined as that part of the Earth where living things normally exist. Still less is Gaia the same as biota, which is simply the collection of all living organisms. The biota and the biosphere taken together form part but not all of Gaia. Just as the shell is part of a snail, so the rocks, the air, and the oceans are part of Gaia.[109]

Lovelock continues that, our earth, being consisted of atmosphere, organisms and non-living matter, is also subject to homeostatic conditions, and that make Gaia theory closer to equilibrium view of ecosystem science:

> Gaia theory predicts that the climate and chemical composition of the Earth are kept in homeostasis for long periods until some internal contradiction or external force causes a jump to a new stable state.[110]

Lovelock also gives information on how the negative feedback system of Gaia works.[111] He writes in his book that when he first presented his theory at the end of 60s, he suggested that negative feedback functions due to the act of organisms; that living matter collectively work to bring forward the self-regulative capability of the planet. He puts that later he refuted his own theory, and assumed that Gaia is not bound up to organic actions. Rather, there is an inherent cybernetic mechanism

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108 The author became acquainted with James Lovelock’s hypothesis through Donald Worster’s book *Nature’s Economy*. See Worster, *Nature’s Economy,* p. 378. Further information about Lovelock’s systems view can be supplied from the book entitled *The Turning Point* by Fritjof Capra, pp. 284-285.
109 Lovelock, 1995, pp. 15-19.
110 Lovelock, p. 12.
111 Lovelock, p. 20.

inside Gaia that automatically controls the function of organisms and non-living environment to maintain its stability:

> Through Gaia theory I now see the system of the material Earth and the living organisms on it, evolving so that self-regulation is an emergent property. In such a system active feedback processes operate automatically and solar energy sustains comfortable conditions for life. The conditions are only constant in the short term and evolve in synchrony with the changing needs of the biota as it evolves. Life and its environment are so closely coupled that evolution concerns Gaia, not the organisms or the environment taken separately. [112]

Here, he assumes that, like organisms operating their negative feedback mechanisms automatically, earth has also an intuitive cybernetic mechanism, meaning that it is alive. Furthermore, he writes in his book that he tested his theory with a long-term experiment.[113] Here, he developed small ecosystems consisting of daisies as living entities; helium, oxygen and hydrogen gases as inorganic substances; and a specific climate regime having the temperature 20 C. He found out that daisies alter climatic conditions and the percentage of abiotic substances with regard to a homeostatic mechanism resembling the one of our planet. Accordingly, though Lovelock claims that both daisyworld's and earth's self-regulatory mechanism is automatic, he rejects the idea about living systems functioning like a thermostat:

> Daisyworld differs profoundly from previous attempts to model the species or the Earth. It is a model more like those of control theory, or cybernetics as it is otherwise called. Such models are concerned with self-regulating systems; engineers and physiologists use them to design automatic pilots for aircraft o to understand the regulation of breathing in animals, and they know that the parts of the system must be closely coupled if it is to work. In their parlance, Daisyworld is a closed-loop model. Devices that are not self-regulating are often unstable and engineers refer to them as "open loop"; the loops are the feedback links between the parts of the system. Daisyworld is not identical in form to an engineered device; a key difference is the absence in Daisyworld, and perhaps in Gaia also of "set points". In manufactured systems, the user sets the temperature, the speed, the pressure, or any other variable. The value chosen is the set point, and the goal of the system is to keep that value however the external environment changes. Daisyworld does not have any clearly established

[112] Lovelock, p. 20.
[113] Lovelock, p. 31.

> goal like a set point; it just settles down, like a cat, to a comfortable position and resists attempts to dislodge it.[114]

In the above remarks, Lovelock seems to criticize ecosystem theory for its reduction of earth to a thermostat. According to him, earth is not a machine; rather, it is "like a cat". Indeed, as Golley informs us, ecosystem scientists did not approve superorganism hypotheses either.[115] According to him, the main reason for ecosystem disapproval was superorganism theories' assumptions concerning the dependency of living entities to a particular living being. Ecosystem theory assumes that both organic, but also inorganic issues are vital for life on earth. On the contrary, superorganism theory predicts that organic issues are prominent for life. It assumes that both biotic units and abiotic environment are bound up to the system belonging to an organic individual. It is necessary to inform here that superorganism theories and ecosystem theory diversion has a historical background. Briefly, as Golley enlighten us, the first scientist that associated the behavior of living population with the one of a single organism was the biologist Fredric Clements.[116] Clements analyzed variety of plant communities within different landscapes. Then in 1916, he assumed that the totality of plants respond to environmental conditions as if they were a single organic being -"superorganism" he put it- as the result of community interaction. Moreover, he suggested that the interaction in the form of competition or mutualism is the reason for plants' progressive growth and survival. The completion of organisms' progressive development is called *ecological succession.* Clements called the plant population completing its pattern of development as *climax community.* Clements suggested that plant community becomes a single organic unit, a superorganism, in the way to ecological succession. Lovelock's view on superorganismic earth recalls Clements' theory, that both harbor the idea about environment being bound to the organic conditions of existence. Indeed, Clements' superorganism theory was subject to ecosystem disapproval at that time as well. The ecosystem ecologist Arthur Tansley rejected Clements' approach for the lack of

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[114] Lovelock, p. 58.
[115] Golley, 1993, p.201.
[116] Golley, pp.12-13.

emphasis on abiotic factors and environmental conditions necessary for survival.[117] He renounced Clements for developing hypotheses solely through biotic interactions.

Nevertheless, Eugene Odum's statements in an interview confirmed that ecosystem science did not totally condemn Gaia hypothesis:

> The Gaia hypothesis is certainly top-down and holistic, and it's now generally accepted- although there's much discussion as to whether it's self-organized. Organisms have not just adapted to different physical environments; they also modify and improve the environment for their own good.[118]

Here, we learn that though ecosystem theory is suspicious about earth behaving like an organism, it supports Lovelock's theory for its being holistic. Nevertheless, following a holistic approach in science did not indicate Lovelock's ignorance of -what Eugene Odum calls- "reductionistic ecology", requiring a study of species and their behavior in a natural organization. In his book, Lovelock writes that investigating living entities is as important as examining the total system.[119] However, he adds that top-down analysis says the last word on organic growth and evolution. He concludes that organisms can modify their environment just as environment alters living matter with regard to the Gaia system.

Accordingly, the historian of environmentalism Andrew Dobson puts that a dispute on the existence of internal motivation introduced theological convictions to Gaia hypothesis.[120] Indeed, Lovelock does not deny that Gaia embraces theology:

> What I have written so far has been a testament built around the idea of Gaia. I have tried to show that God and Gaia, theology and science, even physics and biology are not separate but a single way of thought.[121]

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[117] McIntosh, 1988, p. 254.
[118] Odum in Tom Chaffin, 1998, "Whole-Earth Mentor: A Conversation with Eugene P. Odum". See the following website: http://www.findarticles.com/cf_dls/m1134/n8_v107/21191216/print.jhtml
[119] Lovelock, 1995, p. 30.
[120] Andrew Dobson, 1995, *Green Political Thought.* London and New York: Routledge, pp. 43-47.
[121] Lovelock, 1995, p. 199.

Environmentalist ideologies developing at the end of 60s took advantage of such combination of scientific and social scientific aspects in systems sciences. It was understood that while ecosystem theory calls for a technological expertise to control nature, Gaia theory unites the natural and the mystical, as believed in the primitive cultures, through science. Nevertheless, we learned that ecosystem theory also puts forward primitive attitudes alongside their technocrat sensibility. A reminder can be put here about the bioregionalist convictions of ecosystem theory. The idea on the cooperation of individuals via their traditional living patterns is embraced in ecosystem scientific assumptions. We will learn in the subsequent chapters that both the technicist and the traditionalist assumptions, as put forward in systems sciences, found an echo in architecture as well.

The discrepancy in the attitudes to nature in systems sciences provided a basis for discrepancies in environmentalism disputing under the labels of "technocentrism" and "ecocentrism".[122] While technocentric approach necessitated an engineered expertise in protecting living systems, ecocentric outlook denies any means of human subjugation and claimed the total dependency on regionalist kinship and the belief in the self-capability of goddess earth. Despite that, both theories laid out the foundations of an environmentalist ethic. The scientific confirmation of human dependency on natural systems ascended the public valuation of nature. The radical ecocentric branches like "Deep Ecology" benefited a great deal from the idea of human-nature interdependence. The historian David Pepper writes the following:

> Deep ecologists deny any separation (that humans and nature are separate, and humans are most important). They claim *'a total field view'*, where every living being is part of Gaia, and has intrinsic value. As Naess puts it, all organisms are 'knots in the biospherical net or field of intrinsic relations', and the very notion of a world composed of discrete separate things is denied.[123]

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[122] The details of the philosophies of both views can be found in David Pepper, 1996, *Modern Environmentalism,* London and New York: Routledge.
[123] Pepper, p. 23.

Both ecosystem theory and Gaia approach built up a bridge between scientific and sociological worldviews in that sense. Furthermore, their affiliation with thermodynamic science rendered the development of a bridge between biological sciences and the other domains of 'hard' science. As Lovelock writes:

> Can we scientists, any of us, do better in our quest to understand life? There are three equally powerful approaches: molecular biology, the understanding of those information processing chemicals that are the genetic basis of all life on Earth; physiology, the science concerned with living systems seen holistically; thermodynamics, the branch of physics that deals with time and energy and that connects living processes to the fundamental laws of the universe. Of these sciences, the latter is the one that may go furthest in the quest to define life. [124]

It is understood that the subjects bringing Gaia theory close to ecosystem view are the endowment of equilibrium view, belief in top-down methodology and the affiliation with the thermodynamic principles. Lovelock assumes that life occurs because our planet remains stable for long periods. However, he warns that earth's capacity of pumping out external pressures is not an indicator of its eternal stability:

> A frequent misunderstanding of my vision of Gaia is that I champion complacence, that I claim feedback will always protect the environment from any serious harm that humans might do. It is sometimes more crudely put as "Lovelock's Gaia gives industry the green light to pollute at will." The truth is almost diametrically opposite. Gaia, as I see her, is no doting mother tolerant of misdemeanors, nor is she some fragile and delicate damsel in danger from brutal mankind. She is stern and tough, always keeping the world warm and comfortable for those who obey the rules, but ruthless in her destruction of those who transgress. Her unconscious goal is a planet fit for life. If humans stand in the way of this, we shall be eliminated with as little pity as would be shown by the micro-brain of an intercontinental ballistic nuclear missile in full flight to its target. [125]

The theoretician of political ecology Andrew Dobson claims that one might consider Gaia theory anti-humanist, in it's assumptions that earth wipes out humanity from its surface, if humanity continues to threaten earth.[126] However, he adds that the lack of

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[124] Lovelock, 1995, p. 21.
[125] Lovelock, p. 199.
[126] Dobson, 1995, p. 46.

humanitarian connotations in Gaia does not indicate its departure from anthropocentric concerns:

> So while the Gaia hypothesis might indeed lead us to contemplate our humble place in the grand scheme of things and thus to a 'decentring' of the human being, we quickly return to centre stage as humility turns into fear for survival.[127]

In this sense, Gaia hypothesis is one of the systems explanations about how life exists on earth. Though Lovelock claimed his theory's divergence from ecosystem idea for the reason that it suggested a "depressing picture of our planet as a demented spaceship"[128], he also brought forward a gloomy outlook warning the termination of humankind unless humans continue to exploit environment for their own will.

2.5.1. Self-Organizing Earth

As outlined in the previous article, Gaia theory assumes an internal living system inside earth, which controls both biotic and abiotic environment. As Lovelock put, "I found it reasonable to call Earth alive in the sense that it was a self-organizing and self-regulating system".[129] The theory of self-regulation was explained earlier; however a reminder may enlighten the reader. The systems ecologist Eugene Odum defines self-regulation as a process during which the internal configuration of a closed ecosystem changes until it becomes stable. He puts that a natural organization in which its species are well-adapted to their environment via evolution is the most successful one for self-regulation. In a self-regulatory ecosystem, species automatically control their reproduction rate and the amount of input food necessary for survival. It is as if a homeostatic machine is built inside them during evolution, which regularly arranges production and consumption. We also learned that Lovelock claims that our planet is self regulating because of its having a homeostatic

[127] Dobson, p. 46.
[128] Lovelock in Dobson, p. 45.
[129] Lovelock, 1995, p. 31.

mechanism that modifies species and climatic conditions for a stable environment. As a result, the theory of self-regulation conforms to the equilibrium picture as stated in systems ecology.

Furthermore, as Lovelock puts and cited in the previous paragraph, earth is not only a self-regulating, but also a self-organizing entity. Then, another question might be what self-organization refers to. Today, the principle of self-organization in the systems sciences is explained in a disequilibrium perspective, which is theorized by getting help from the evolutionary principles, and in this way it diverts from equilibrium perspective of the principle of self-regulation. Briefly, as the scientist Francis Heylighen enlightens us, in biological sciences, self organization indicates "a process of evolution where the effect of the environment is minimal, i.e. where the development of new, complex structures takes place primarily in and through the system itself." [130] From above explanation, we can understand that by assuming on self-regulation, Lovelock envisioned earth as evolving regardless of outside environmental conditions.

Heylighen continues to inform us that in contemporary biology, evolution by self-organization is considered as an alternative to Darwinian evolution by natural selection. Darwinian postulate conceives evolution as a selective process carried on by exterior environment in which species compete for resources. Those who are most adaptive to the conditions put by the environment, in terms of attaining resources for the continuation of progeny are selected and others are eliminated. Though genetic science was not developed in those years, Darwin theorized that competitive struggles may well undergo between members of same species in which genetic variation occurs as the result. In this sense, in Darwin's theory, biological entities are supposed to modify their structural organization progressively, with regard to the selective environment. Accordingly, Heylighen informs that the difference between Darwinian natural selection and self-organization is that while the former needs the existence of living environment having the same species with the one that is to

[130] Francis Heylighen, 1997, "Self-Organization", in the *Principia Cybernetica Web*, http://pespmc1.vub.ac.be/SELFORG.html, (accessed Sep. 2005).

evolve, the latter does not need such an existence. Moreover, there is another difference. Darwinian evolution occurs in a system in which the availability of resources is limited. However, a self-organizing system can evolve without the constraints set by the outside environment. In fact, evolution toward self-organization assumes natural selection as well. A living unit can be naturally selected towards a goal without the need for an environment having the same type of entities in self-organizing evolution. Heylighen explains natural selection of self-organized systems in the following statement:

> Darwinian evolution cannot explain the evolution of a "population of one". In our present, more general interpretation, there is no need for competition between simultaneously present configurations. A configuration can be selected or eliminated independently of the presence of other configurations: a single system can pass through a sequence of configurations, some of which are retained while others are eliminated. The only "competition" involved is the subsequent states of the same system. Such selection can still be "natural".
>
> More importantly this selection does not in any way presuppose the existence of an environment external to the configuration undergoing selection…A cloud of gas molecules in a vacuum will diffuse, independently of any outside forces. A crystal in the same vacuum will retain its rigid crystalline structure. The first configuration (the cloud) is eliminated, the second one maintains. The stability of the structure, functioning as a selection criterion is purely internal to the configuration: no outside forces or pressures are necessary to explain them.[131]

From above remarks, it is understood that contemporary biology considers the theory of evolution by self-organization as an alternative to the Darwinian theory of evolution by natural selection. It seems that Lovelock acknowledges to the self-organization theory in order to provide a plausible explanation regarding how earth modifies its own internal structure. Accordingly, Heglighten continues to inform about another characteristic of self-organization as suggested in contemporary biology: He puts that aside from taking place under the minimum influence of external environment, self-organization occurs in a positive feedback, as well as in a negative feedback condition. However, in systems ecology, it is assumed that life cannot be possible in positive feedback situation. Positive feedback in a system

[131] Heylighten.

indicates that the system is unstable and leads to death. It was mentioned earlier that Eugene Odum considers positive feedback in a mechanical system as an accelerator of destruction. Then, how can life occur in an unstable situation? According to the chemist Ilya Prigogine, exceeding of threshold conditions may lead to the formation of new biological structures; that negative feedback is not the only means of evolution and survival.[132] In his book, he puts that evolution results in disequilibrium conditions as well. He postulates that supra molecular entities, which he calls "dissipative structures", evolve in positive feedback situations.

Prigogine's ideas were influential in the paradigm shift in systems ecology, from equilibrium to disequilibrium perspective. He puts that evolution occurs not only in stable conditions, but also in unstable conditions. The philosopher of systems science, Fritjof Capra summarized the situation in the following:

> The basic dynamics of evolution, according to the new systems view, begins with a system in homeostasis- a state of dynamic balance characterized by multiple, interdependent fluctuations. When the system is disturbed it has the tendency to maintain its stability by means of negative feedback mechanisms, which tend to reduce the deviation from the balanced state. However, this is not the only possibility. Deviations may also be reinforced internally reinforced through positive feedback, either in response to environmental changes or spontaneously without any external influence. The stability of a living system is continually tested by its fluctuations, and at certain moments one or several of them may become so strong that they drive the system over an instability into an entirely new structure, which will again be fluctuating and relatively stable. The stability of living systems is never absolute. It will persist as long as the fluctuations remain below a critical size, but any system is always ready to transform itself, always ready to evolve. This basic model of evolution, worked out for chemical dissipative structures by Prigogine and its collaborators, has since been applied successfully to describe the evolution of various biological, social and ecological systems.
>
> There are a number of fundamental differences between the new systems theory of evolution and the classical neo-Darwinian theory. The classical theory sees evolution as moving toward an equilibrium state, with organisms adapting themselves ever more perfectly to their environment. According to the systems view, evolution operates far from equilibrium and unfolds through an interplay of adaptation and creation. Moreover, the systems theory takes

[132] Prigogine and Stengers, 1984, p. 140.

> into account that the environment is, itself, a living system capable of adaptation and evolution. Thus the focus shifts from the evolution of an organism to the coevolution organism plus environment.[133]

Lovelock assumes that earth goes through both self-regulation and self-organization, while determining the conditions for life. We saw that while the theory of self-regulation belongs to an equilibrium picture as stated in systems ecology, the theory of self-organization underwent a disequilibrium picture after Prigogine. Lovelock benefited from both assumptions especially regarding his ideas on the evolution of earth. Indeed, he himself points to that he was influenced by Prigogine's views.[134] Therefore, we observe Lovelock's shift of vision from equilibrium to disequilibrium perspective.

The concluding remark will be the summary of Lovelock's ideas on earth that he developed regarding both perspectives. Briefly, he suggests that earth for a long time is subject to equilibrium conditions. At that period, it remains in a negative feedback situation and provided regular volume, pressure or temperature conditions for the survival of organisms. Furthermore, earth is also subject to self-organization in this equilibrium situation. It modifies its own internal structure with regard to this equilibrium environment and remains in a negative feedback state. Nevertheless, Lovelock envisioned the human destruction of the stable state governing earth for millennia. Like ecologist Eugene Odum before him, he assumes of human production and consumption being a major threat to earth's stability. The condition of earth being forced by human threat indicates that it is exposed to positive feedback. Positive feedback means the uniform temperature and volume conditions on earth are disrupted and thus the self-regulatory systems are damaged. Here, he refers to the disequilibrium vision and claims that earth can organize itself despite being in positive feedback. It will not lead to a decease following the surpassing of negative feedback situations. Rather, it will go through self-organization and gain a new state of being. Therefore, according to Lovelock, the annihilation of self-regulatory

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133 Capra, 1983, p. 286.
134 Lovelock, 1995, p.202.

systems does not point to the death of earth, rather it points to the death of humanity. He assumed of a model of earth reorganizing itself to shift from one stable state to another. He put forward the idea of earth evolving into a different type of stability by self-organizing itself. In this sense, he displayed a depressing view by claiming that the restructuring of earth might result as human's substitution in favor of more benign species.

2.6. The Shift from Earthly Balance to Flux: The "Order through Fluctuation" Approach of Ilya Prigogine

As mentioned earlier, the physicist Shrödinger tries to find an answer to the following question: if the entropy increase is the condition for all mechanical, chemical or biological systems, then how can we explain life occurring in spite of decay? His theory of negative entropy put forward the idea concerning the possibility of an organism adjusting the flow of energy and matter to sustain its self-regulation. Ecosystem theory followed this view; it assumed that ecosystems are in a state of minimum entropy production, with the aid of their thermostatic mechanisms. However, after the 70s, the explanations concerning the necessity of equilibrium state to sustain life is contested by the new generation of system theorists.[135] They claimed that open systems could evolve in unstable conditions as well. However, they did not refute that homeostasis is necessary to preserve the steady state of a living system in a certain period of time, even though it is not obligatory to maintain life. They point out therefore, both being in equilibrium and being in disequilibrium state is important. The following paragraphs will inform the reader about one of the representatives of this disequilibrium picture, the chemist and the systems scientist Ilya Prigogine. In fact, Prigogine was referred in the above paragraphs regarding his knowledge on thermodynamics. Unlike the post-war systems scientists, Prigogine is

[135] The scientist and philosopher Fritjof Capra briefly introduces us about the new generation of systems scientists and their views, in his book entitled the turning points. See Capra, 1983, *The Turning Point: Science, Society, and the Rising Culture*, New York: Bantam Books pp. 265-305.

involved with evolutionary theories in ecology. As mentioned earlier, the growing interest to evolutionary approach in the ecological sciences is the reason for the change of attitudes in systems sciences. In the subsequent section, Prigogine's views will be outlined with regard to his book *Order out of Chaos*, which he wrote with the philosopher Isabelle Stangers.

In the book, Prigogine defines his vision under the name "far-from-equilibrium theory" that he developed via the help of both thermodynamic physics and evolutionary ecology. We will begin with the following paragraphs from the book, indicating that Ilya Prigogine does not refute the equilibrium theory at all:

> It is true that when we come to a biological system such as the bacterial chemotaxis, it is hard not to speak of a molecular machine consisting of receptors, sensory and regulatory processing systems, and motor response. We know of approximately twenty or thirty receptors that can detect highly specific classes of compounds and make a bacterium swim up spatial gradients of attractants or down gradients of repellents. This "behavior" is determined by the output of the processing system-that is, the switching on or off of a tumble that generates a change in the bacterium's direction.
> But such cases, fascinating as they are, do not tell the whole story. In fact it is tempting to see them as limiting cases, as the end products of a specific kind of selective evolution, emphasizing stability and reproducible behavior against openness and adaptability. In such a perspective, the relevance of the technological metaphor is not a matter of principle but of opportunity.[136]

Here, Prigogine and Stengers put that some living entities behave like a thermostat of a machine while they are in equilibrium. Like Odum, they outline the stable condition with a machine metaphor. Nevertheless, they believe that conforming to the boundaries of stable environment is not the only possibility for evolution.[137] An organism can leave its homeostatic state and can adapt to the new condition developed out of positive feedback. A living entity can create a new pattern of stability out of an instable phenomenon. Firstly, it fluctuates between upper and lower boundary conditions; and then "order through fluctuations" may appear as the

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[136] Prigogine and Stengers, 1984, p. 175.
[137] Prigogine and Stengers, pp. 175-176.

outcome.[138] In this sense, instability can be a sign of evolution, rather than death. In an instable state caused due to positive feedback:

> ..certain fluctuations, instead of regressing, may be amplified and invade the entire system, compelling it to evolve toward a new regime that may be qualitatively quite different from the stationary states corresponding to minimum entropy production.[139]

As mentioned earlier, the physicist Shrödinger assumes that organisms should be subject to constant equilibrium conditions in order to live. He believed that their metabolism helps them to be in homeostasis. Furthermore, we learned that the ecologist Eugene Odum believed in the existence of an inherent homeostatic mechanism in not only in organisms, but also in biological systems, helping them to remain in a state of equilibrium. However, Prigogine and Stengers claim that equilibrium cannot be the only precondition for life.[140] According to them, biological systems are open organizations, which cannot be in constant equilibrium state, because of their continuous exchange of energy and matter from outside. A system can only be in a continuous state of equilibrium when it is isolated from its environment. Prigogine and Stengers writes the following: "In order to produce equilibrium, a system must be 'protected' from the fluxes that compose nature. It must be 'canned', so to speak, or put in a bottle".[141]

As it was mentioned earlier, Prigogine and Stengers did not refute the equilibrium picture of living systems at all. They put that living systems may temporarily be in equilibrium state. Therefore, as Bertalanffy informs us, equilibrium conditions are twofold: one is, constant equilibrium in a closed system, the other is, permanent equilibrium in an open system.[142] Mechanical systems might conform to this constant equilibrium picture as it is possible to isolate the system from its environment, such that we can arrange temperature conditions inside the system. As mentioned before,

[138] Prigogine and Stengers, pp. 167-168.
[139] Prigogine and Stengers, p. 140.
[140] Prigogine and Stengers, p. 175.
[141] Prigogine and Stengers, p. 128.
[142] Von Bertalanffy, 1968, pp. 124-125.

in a closed thermodynamic system, energy but not matter is exchanged between itself and its surroundings. Therefore, in a closed system, it is possible to control exchange of heat, thus to avoid the production of entropy. As mentioned earlier, the ecosystem ecologist Eugene Odum envisions ecosystems as closed entities, like space capsules, in which it is possible to achieve equilibrium conditions by manipulating energy inside. Contrary to this, Prigogine and Stengers inform us that it is not possible to control entropy production in biological systems.[143] As they put, "living nature is profoundly alien to the models of thermodynamic equilibrium".[144]

We learned that Prigogine and Stengers use mechanical analogies for a biological entity while speaking about homeostasis. Yet, they add that even though homeostasis is not always a prerequisite for mechanical systems.[145] Sometimes mechanical organizations are also subject to far-from-equilibrium situations. They write for instance, if the boundary heat is surpassed in a hydraulic system, the molecules inside the liquid begin to fluctuate in the upper and lower limits. That means the hydraulic system is pushed beyond the threshold of stability, which is called "bifurcation" state in physics. When exceed of heat is continuous, the liquid begins to oscillate more violently and "the transition to chaos is complete".[146] (Fig. 2.4.) Accordingly, they inform us that a system produces maximum entropy when it is fluctuating at the threshold of stability. They point out that the maximum entropic condition is called "bifurcation point" in physics. Here, an unexpected phenomenon occurs; the molecules inside the liquid go through a different pattern of organization by arranging the rate of fluctuations. An orderly phenomenon out of a fluctuating system appears. They continue that equilibrium is not always a required issue in chemical systems either. Sometimes particular types of chemical substances, that are called "catalysts", may alter stability by modifying, "the reaction rate without being changed in the process" as they writes.[147] Catalysts can accelerate or decelerate the reaction rate and cause the chemical composition to undergo a different type of

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[143] Prigogine and Stengers, 1984, p. 127.
[144] Prigogine and Stengers, p.127.
[145] Prigogine and Stengers, p. 175.
[146] Prigogine and Stengers, p. 167.
[147] Prigogine and Stengers, p. 133.

organization that is different than its usual state. They inform that in biological organizations, ‘enzyme’, which is a particular protein, is a catalyst of many chemical reactions, which occur inside the body. Therefore, biological organizations are subject to far-from-equilibrium conditions as well.

In this sense, “order through fluctuations” principle contests the assumption about negative feedback being the only means of growth and survival in living systems. Ecosystem view considered the dependency of living systems to the equilibrium picture. In that, an ecosystem leads to extinction when it is subject to fluctuations occurring due to exceed of threshold conditions. Contrary to this, Prigogine and Stengers stated that the creation of an active state of material might result from fluctuation, rather than termination.[148] In this sense, “life is interplay of adaptation and creation”, in the words of the philosopher Fritjof Capra.[149]

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[148] Prigogine and Stengers, p. 168.
[149] Capra, 1983, p. 286.

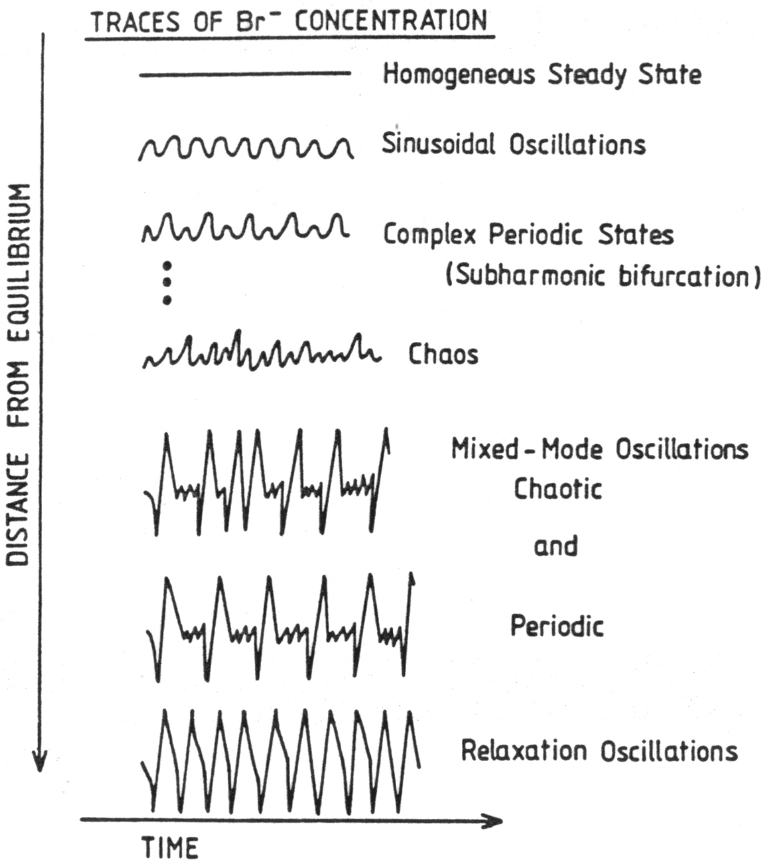

Fig. 2.4. The "order through fluctuations" diagram of Prigogine and Stengers.
Source: Prigogine, Ilya and Isabelle Stengers. 1984. *Order out of Chaos.* New York: Bantam Books.

2.6.1. The Role of History and Chance in Biological Systems

Prigogine and Stengers conclude their book with their ideas on the behavior of organisms and ecosystems in this disequilibrium picture.[150] Briefly, they emphasize that a living entity always has a tendency to reach a steady state, even though it does not strive for keeping the same type of stability for a long time. Therefore, both homeostatic and catalytic processes are important for organic evolution. They continue that mostly, a living entity arranges its own pattern of steadiness by

[150] Prigogine and Stengers, 1984, p. 189.

considering its previous condition. That means it takes its history into account for having a steady state. However, they point out that sometimes there are certain conditions, in which chance is determinant, rather than history.[151] Here, they exemplify DNA structures, which determine a steady-state condition accidentally. As information, DNA is a chemical substance, which is primarily found in the nucleus of cells and which carry genetic information. Briefly, DNA involves with some chemical reactions in the body while evolving. Usually, among these chemical reactions, it selects which to involve with, by taking its past state of evolution. However, sometimes these alternatives are so identical in general condition that the DNA determines which one to involve by chance. As a result, DNA determines its pattern of stability randomly. We can summarize this subject-matter with the following citation from the philosopher Fritjof Capra:

> The internal reinforcement of fluctuations and the way the system reaches a critical point may occur at random and unpredictable, but once a critical point has been reached the system is forced to evolve into a new structure. Thus chance and necessity come into play simultaneously and act as complementary principles. Moreover, the unpredictability of the whole process is not limited to the origin of instability. When a system becomes unstable, there are always at least two new possible structures into which it can evolve. The further the system has moved from equilibrium, the more options are available. Which of these options is chosen is impossible to predict; there is true freedom of choice. As the system approaches its critical point, it "decides" itself which way to go, and this decision will determine its evolution.[152]

Moreover, Prigogine and Stengers continue to enlighten us about the behavior patterns of organisms according to the current systems view.[153] They point out that, in this picture, life develops out of not only the interplay of feedback systems, but also out of the interrelation of cooperation and competition. Firstly, they remind us about the conventional evolutionary assumption on competition. They interpret this picture in thermodynamic terms. Briefly, they point out that evolutionary approach envisions a competition between organisms in order to remain in a thermodynamic

[151] Prigogine and Stengers, p.163.
[152] Capra, 1983, p. 288.
[153] Prigogine and Stengers, 1984, pp. 187-189.

steady-state. In a steady-state ecosystem, material and energy resources are in sufficient limits for every species. The species need to struggle to obtain a piece from this limited resource; however, the energy and material exchange during the struggle sustain the equilibrium of their ecosystems. As mentioned earlier, this picture is also announced by Eugene Odum. He stated that evolutionary adaptation works in stable conditions. However, Odum depicted the organic relations in terms of mutual relations, rather than competition.

Accordingly, as Worster informs us, before this new systems view is put into place, cooperation approach of ecosystem theory was contested in favor of competition approach, because of the re-integration of evolutionary paradigms into ecological science.[154] As we mentioned earlier with reference to the historian Golley, the discipline of ecology was subject to the rise of evolutionary view a decade after the war. Worster mentions about the same issue and point out that this rise is because of the growing concern on population ecologists' studies, who interpret environment in terms of evolutionary paradigms. Basically, as Worster puts, population ecologists observed that there is not a cooperative relation in a population. Every species are subject to struggle and behave individualistically in order to survive. Moreover, they found out evidences to refute James Lovelock's theory that earth strives to remain in a steady-state. On the contrary, they found out that earth is the collection of climatic irregularities. Living entities make self-centered decisions to remain in that irregularity. Furthermore, Worster puts that some ecologists put that species take into their history while making an individual decision; some believe that their decision is random. He informs that these ecologists contested the earlier evolutionary assumption regarding 'competition being determinant for equilibrium' as well. Accroding to them, there is not any equilibrium state in this picture, and there is a competition going on in that disequilibrium environment. Worster points out that the population ecologists introduced certain terminologies depicting the unstable condition of environment, such as "disturbance", "patch", "diversity", "chaos",

[154] Worster, 1995, pp. 388-433.

“disorder”, “discrete” etc.[155] Furthermore, as Worster puts, these newly introduced ideas reflect the social and political flows.[156] As mentioned earlier, the stability vision embraces a rigid economic structure, in which corporate assembly in a division of labor. However, the new picture embraces a world-view in which individuals have a freedom of choice and get along with a changing environment.

It is understood that population ecologists envisioned the disequilibrium in terms of competition. Accordingly, competition also assumed in the new systems view, however, as Capra puts, struggle for survival takes place “in the wider context of cooperation”.[157] As Prigogine and Stengers inform us, according to the new systems view, when the stability is threatened, cooperation among organisms becomes necessary to develop new stability out of this unstable phenomenon.[158] They exemplify slime molds in this context. Basically, slime molds cooperate and organize themselves into an ecosystem when there is an unstable condition, for instance, the scarcity of resources. In that situation, they come together and develop a massive volume to inhabit spores, which are bacterial cells. The newly accommodating spores arrive at the food and energy resources for these slime molds. In this picture, cooperation determines survival. Another example is viruses, as provided by Capra.[159] Viruses are microorganisms with a nucleic acid. When they want to invade a certain bodily organism, they compete with this organism’s cells by cooperating with the other particular cells of the body. They combine with these particular cells to form a system consisting of virus-cells, struggling with the healthy cells in order to give way to a disease. Capra summarizes the picture: “In a balanced ecosystem, animals and plants live together in a combination of competition and mutual dependency.”[160] As a result, we may say that the interrelation of cooperation and competition determines the ways in which a living entity relates with its ecosystem and the general surrounding. The unstable condition may lead to the development of a new stability, resulting out of this interplay.

[155] Worster, p. 393.
[156] Worster, p. 401.
[157] Capra, 1983, p. 279.
[158] Prigogine and Stengers, 1984, p. 159.
[159] Capra, 1983, p. 276.
[160] Capra, p. 279.

2.7. Thermodynamics of Communication

Hence, in the above assumptions, it was suggested that both stability and instability is existing phenomena for the sustaining of life. As Schneider and Kay puts, “Life cannot exist without both processes, order from disorder to generate life and order from order to ensure the continuance of life”.[161] Moreover, we have learned that both competition and cooperation, being the communication models of organisms, have a significant role in this picture. Earlier in this chapter, it was suggested that the patterns of relation between organisms, the “bio-sociological issues” in Hutchinson’s terms, are mostly the concern of evolutionary ecologists. However, that does not indicate that the systems ecologists were not concerned about how social relations took place during the exchange of energy and matter. Basically, as mentioned earlier, systems ecologists assume a cooperative bond. That assumption was contrary to those of evolutionary ecologists on the competitive struggle, operating under the selective mechanism of nature. The discrepancy between the views about social patterns of organisms is contested by later generation of systems scientists, under the new picture, which is, as Capra puts, “struggle in the wider context of cooperation”.

In the above paragraphs, we have seen that systems theory interpret social relations in terms of thermodynamic principles. Hence, this article will give brief information about how thermodynamics entered into systems theories on social interaction. Basically, thermodynamic principles became a basis for the subject-matter with the help of information theory, which was developed by the mathematician Claude Shannon.[162] He was famous for his studies on how information is passed in mechanical systems, such as, radio, telegraph or satellite network. As the biographers N.J.A. Sloane and A.D. Wyner inform us, Shannon published the basic aspects of his

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[161] Schneider and Kay in Glenn Albrecht, 1997, *Organic Unity and the Limits of Conventional Justice*, http://www.arbld.unimelb.edu.au/envjust/papers/allpapers/albrecht/home.htm, (accessed Jun. 2003).

[162] The author was informed about the impact of information theory to the systems ecology from Bertalanffy’s book entitled *General System Theory.* Moreover, the author became acquainted with the place of information theory in systems ecology from Ramon Margalef’s book entitled *Perspectives in Ecological Theory.*

theory in an article "The Mathematical Theory of Communication" in 1948.[163] The article appeared in a journal of a telecommunication firm in which he worked at that time. He found out that information can be treated like a measurable physical quantity, such as density or mass.[164] Moreover, he discovered that certain amount of information sent via a communication system is lost, while passing from the sender to the receiver. Shannon named this loss of information as "entropy", the identical name indicating the loss of useful energy producing motion. Accordingly, it was indicated in the earlier paragraphs that entropy has always a positive value due to its incessant increase in any system. It was also mentioned that Shrödinger turned the mathematical identification of entropy into a negative denomination and labeled it as "negentropy". He assumed that the metabolism of biological systems is negentropic in the sense that they help in the resistance to degradation. Shannon found out that the same mindset can be applicable to the communicative processes; that while entropy *S* reveals the amount of lost information, negentropy as the logarithm *1/S* shows the extent of information.[165] Shannon's theory proved that exchange of information is subject to entropic relations, like that of energy and matter.

Consequently, Shannon's assumption on the thermodynamic means of communication found a place in systems theory. In 1968, systems theorist and biologist Ludwig von Bertalanffy outlines the association between systems science and information theory in the following:

> Another development which is closely connected with system theory is that of the modern theory of communication…Entropy is a measure of disorder; hence negative entropy and information is a measure of order or of organization...A second central concept of the theory of communication and control is that of feedback. So a great variety of systems in technology and in living nature follow the feedback scheme, and it is well-known that a new discipline, called Cybernetics, was introduced by Norbert Wiener to deal with these phenomena. The theory tries to show that mechanisms of a feedback nature are the base of teleological or

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[163] N.J.A. Sloane and A.D. Wyner, 2003, "Biography of Claude Elwood Shannon", http://www.research.att.com/~njas/doc/shannonbio.html. (accessed September 2005).
[164] "Bell Labs Celebrates 50 years of Information Theory", 2004, http://www.lucent.com/minds/infotheory/docs/intro.pdf (accessed March 2006)
[165] "Bell Labs Celebrates 50 years of Information Theory", 2004.

purposeful behavior in man-made machines as well as in living organisms, and in social systems.[166]

Here, Bertalanffy announces that information exchange is also subject to negative feedback; that homeostasis is applicable to communication systems. His assumptions display that the theory of communication is transformed to the systems sciences with regard to the equilibrium vision. Accordingly, the above remarks display that Bertalanffy envisioned the equilibrium picture not for mechanical or biological systems, but also for social organizations as well.

In 1969, the Spanish ecologist Ramon Margalef published a book with the title *Perspectives on Ecological Theory*, in which he theorized ecosystem patterns of relations in terms of information currents. Hence, it seems that information theory entered into the sight of ecosystem ecologists just after it became a source of discussion in the systems sciences. In the book, Margalef claims that ecosystems keep in a stable structure owing to the exchange of information between organisms; that communication is prerequisite for stability:

> Any system formed by reproducing and interacting organisms must go on to develop a kind of assemblage in which the production of entropy per unit of preserved and transmitted information is at minimum. The structures that endure through time are those that are most able to influence the future with the least expense of energy… In time the acquired information is expressed in a new organization of the ecosystem… One can say that the (successor) ecosystem has 'learned' the changes in the environment, so that before change takes place, the ecosystem is prepared for it, as it happens with yearly rhythms.[167]

The above remarks display that Margalef also endows a stability picture for ecological systems of communication. He believes that the more communication takes place between organisms in a network, the more stable the ecosystem is. Living systems "learn" resistance to decay through continuous exchange of knowledge, like that of energy in the course of time. According to him, an ecosystem, which is

[166] Von Bertalanffy, 1968, p. 39.
[167] Margalef, 1968, p. 29.

successful at being in low entropic state, informs that to the succeeding generation. It teaches the consequent ecosystem the knowledge of stability by exchanging information. In his book, Margalef adds that this condition is also relevant for social systems, sharing knowledge with each other and teaching their experiences to future generations.[168] In this sense, the latter social group is informed via their history in that way.

Margalef's doctrine on the relation between communication and stability was also confirmed by the population ecologist Robert May.[169] Worster puts that May's major focus was energy relations in ecosystems, before he shifted his studies on the stability and instability of populations.[170] He combined both thermodynamics and bio-sociological issues in his studies. As his book suggests, on one hand, May seems to be in congruence with Margalef's stability view, on the necessity of sharing knowledge for a stable development.[171] He suggests that if species continue to communicate and share knowledge among each other, they get hold of their orderly state. On the other hand, his book displays that he disagrees with Margalef that a steady-state environment is bound to the amount of diverse species in living populations. As mentioned earlier, ecosystem ecologists hypothesized that biodiversity is important for a homeostatic environment; the more species are in a living system, the more it is resistant to fluctuations. However, as Worster informs us, May's later experiments on the computer environment displayed just the opposite.[172] He found out that fragility, rather than stability is of concern in a system having diverse species. In this sense, unlike Margalef, he does not seem to endow an equilibrium picture for patterns of relation. Complexity of relations in a diverse environment ascends the weakness of a living system. Worster informs that May's thesis is in congruence with the other population ecologists at that time.[173] As

[168] Margalef, pp. 16-17.
[169] The author was informed about Robert May through Worster's book *Nature's Economy*. See pp. 408-410. For a detailed inofmrtion on May's hyphotheses, see Robert May, 1973, *Stability and Complexity in Model Ecosystems,* Princeton: Princeton University Press.
[170] Worster, 1995, p. 409.
[171] May, p. 67.
[172] Worster, 1995, p. 409.
[173] Worster, p. 410.

mentioned before, population ecologists envisioned a disorderly environment, rather than a stable one. However, May adds in his book that, in diverse environment, if species continue to exchange knowledge among each other, they deal with their fragile condition.[174] They develop into a new stability out of this instable phenomenon. Hence, the continuous sharing of knowledge is the assurance of a stable environment. Prigogine summarizes the issue in the following:

> Indeed, the more complex a system is, the more numerous are the types of fluctuations that threaten its stability. How then, it has been asked, can systems as complex as ecological or human organizations possibly exist? How do they manage to avoid permanent chaos? The stabilizing effect of communication could be partial answer to these questions. In complex systems, where species and individuals interact in many different ways, communication among various parts of the system is likely to be efficient. There is competition between stabilization through communication and instability though fluctuation. The outcome of this competition determines the threshold of stability.[175]

We learned from May that the constant network of communication in a crowded population sooner or later causes the development of new stabilities out of this biodiversity. He approved Margalef's thesis in this sense; by assuming the significance of species interaction for the stability of ecosystems. Accordingly, the conservation biologist Stuart Pimm writes with the following:

> Complexity just makes things very difficult. So build a (computerized) model (of ecosystems) at random and, unless it's really simple (a one-prey-one resource population model) it won't work. Add diversity, interactions, or increase the food chain lengths and soon these get to the point where they will also fall apart. That's the theme of Gardner, Ashby, May and my early work on food webs. But keep on adding species, keep on letting them fall apart, and surprisingly, they eventually reach a mix that will not fall apart. Suddenly one gets order for free...The only way we know how to get stable, persistent, complex systems is to repeatedly assemble them. And as far as I know, no one really understands why that works.[176]

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[174] May, 1973, p.171.
[175] Prigogine, p. 189.
[176] Staurt Pimm in Kevin Kelly, *Out of Control*: *The New Biology of Machines, Social Systems, and the Economic World*, 1994. Online web format is available on the internet. See the following website: http://www.kk.org/outofcontrol/

Hence, communication is prerequisite for the re-development of stability; that order again results out of a disorderly situation. In this sense, sharing of knowledge is important for not only the assurance of stability, but also the re-configuration of other stabilities.

As it was mentioned earlier, Margalef envisioned a stability picture for human systems. Accordingly, historian Manuel de Landa interprets how human organizations operate in terms of the new systems view, which envisions both stability and instability. In his book *A Thousand Years of Non-Linear History*, he points out that urban areas provide a platform for both stable and unstable human informational networks.[177] According to him, whereas administrative units of a city are examples of a stable communication set-up, economic models are the ones of an unstable organization, because they "fluctuate in the supply and demand".[178] Both informational systems have certain impacts on the formation of an orderly urban configuration. In an article, he discusses how cities grow into metropolises by an economic means of fluctuation:

> We may ask what kind of turbulence entered into the mixture of towns like Venice in the middle ages, Amsterdam in the eighteenth century, London in the nineteenth century, and New York in the twentieth century. One possible answer is offered by urbanist Jane Jacobs in *Cities and the Wealth of Nations* (1984). Then she suggests that the process driving these towns far from equilibrium, leading Western towns into a turbulent, auto-catalytic state is "volatile trade". Volatile trade occurs when a city, typically a part of a trading network, begins to replace imports by its own manufactured products and sets a whole series of self-reinforcing, positive feedback loops into motion. To replace imports a city must develop new skills and procedures using its own human resources and local creativity…Jacob's hypothesis is that a dynamic process of "import-substitution" enabled eleventh-century Venice and fifteenth-century London to mature form being exporters of raw materials and importers of manufactured products, to become increasingly self sufficient.[179]

[177] Manuel de Landa, 1997, *A Thousand Years of Non-Linear History,* New York: Swerve Editions.
[178] De Landa, 1997, p. 31.
[179] Manuel de Landa, 1999, "The Non-Linear Development of Cities", in Amerigo Marras (ed.), 1999, *Eco-Tec:Architecture of the In-Between*, New York: Princeton Architectural Press.

Hence, cities are the loci of social communication where information is rapidly transmitted. The flow of knowledge is the guarantee of either the existing stability of a system, or the redevelopment of another order. In this sense, like biological models pertaining to both negative and positive feedback processes, human organizations develop out of both stability and flux. The following statement from De Landa may be a conclusion regarding the subject:

> Negative feedback, as a system of control and reduction of deviation, may be applied to human hierarchies. Decision making in stratified social structures does not always proceed via goal directed analytical modeling but often incorporates automatic mechanisms of control similar to a thermostat (or any other device capable of generating homeostasis). On the other hand, social meshworks (such as the symbiotic nets of producers whom Jacobs describes as engaged in volatile trade) may be modeled on positive feedback loops as long as our model also incorporates a means for the resulting heterogeneity to be interwoven. Moreover, specific institutions will likely be mixtures of both types of reciprocal causality, and the mixtures will change over time, allowing negative or positive feedback to dominate at a given moment. [180]

The systems philosopher Kevin Kelly, in his book *Out of Control,* mentions about a hypothesis, assuming that the intensity of communication depends on the number of species in an ecosystem.[181] In other words, scale is an important factor for determining relationships. He outlines the logic as the following: "…systems with many components would have weak relations between them, while systems that had few components would have tightly coupled relationships".[182] In a stable ecosystem, you have either tight relations and small community; or weak relations and a large community. In fact, this issue is also relevant for human systems. In a small community like a village, for instance, there are more close affinities when compared with those in a metropolitan region. Therefore, in an ecosystem or in a human organization, there are either many loosely-tied relations or few closely-affiliated ones, depending on its scale.

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[180] De Landa, 1999, p. 69.
[181] Kelly, 1994.
[182] Kelly.

2.8. Conclusion: A Summary of the Systems Ideas on Planetary Survival

So far, the basic features of systems ecology are entirely discussed. The place of equilibrium assumptions in ecological sciences and their contest by means of “order through fluctuation” theory is summarized. Prigogine and his colleagues taught us that stability is not necessary for endurance; that any mechanical, chemical or biological organization may well develop in positive feedback state. Moreover, they assumed that life is not solely bound to a system; that a single entity can also have the power to determine life. Any single organism can operate its free will to draw the destiny of its future generations. As we learned from Worster, the importance given to single entity is because of the introduction of “individualism” to the ecological sciences, owing to the population ecologists. The “far-from-equilibrium” vision puts that any single living or non-living entity may organize itself, regardless of an environment.

Accordingly, experiments trying to discover the origins of life in non-living matter began earlier than the emergence of the “order through fluctuation” principle. In the 50s, some scientists observed a system of abiotic substances being subject to the abundant energy flow, which was created through the continual supply of electricity.[183] Here, the abiotic matter was watched in a fluctuating state owing to excessive energy flow. After a while an assembly was discovered for a molecular organization, which was in fact an action of biological systems. In other words, non-living substances acted like living objects in far-from-equilibrium conditions. Therefore, it is probable that life on earth began out of a non-living matter. Hence, self-organization seems to be a more likely explanation than Darwinian selection about the beginning of life on our planet. It is not reasonable to explain evolution of an environment by means of Darwin’s theory, in which the species are not developed

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[183] Harold J. Morowitz, 1989, in “Biology as a Cosmological Science”, in J. Baird Callicott and Roger T. Ames (eds.), *Nature in Asian Traditions of Thought*, Albany: State University of New York Press, p.42

yet. Despite those factors, further experiments are needed to prove the formation of higher organic forms like human body through self-organization. As the scientist Pierre Hohenberg of Yale University writes: “I don’t know a single phenomenon that Prigogine explained.”[184] The main reason for that, which admitted by Prigogine himself, is the lack of quantitative data. The absence of quantitative information on self-organizing entities is due to the impossibility of formulating the pattern of evolution owing to the factors of chance and necessity.

As it was discussed in the previous chapter, systems ecologists were interested in drawing the total picture of earthly relationships owing to their interdisciplinary collaboration. The efforts of seeing the overall picture resulted in manifold hypotheses about the future biological conditions of our planet for human survival. Accordingly, Worster, in his book *Nature’s Economy,* argues that these assumptions are not solely produced under pure scientific mentality; they also reflect cultural models of thinking.[185] He believes that the existence of “imperial” and “arcadian” agendas, being the products of Western cultural set-up since the eighteenth century, has a certain control over the production of these assumptions. Whereas the imperial outlook favors the subjugation of nature through human science and reason, the arcadian belief sought for the return to organic connections with nature as experienced in the primeval times.

As the historian of environmentalism Peter Hay puts, the arcadian quest for idyllic past found its basis in Romanticism in the eighteenth century.[186] He informs us that Romanticism is the movement of reaction against the materialist stance towards nature, which emerged owing to the rise of industrial capitalism at that era. Briefly, Romantic antagonism was against both the immoral consequences of nature’s subjugation and the human alienation from humanitarian values for the sake of rationalism. Despite the Romantic reactions, Hay puts that the Enlightenment thought was mainly on the side of an “imperial” model of nature to be readied for

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[184] Hohenberg in Brig Klyce, 2003, “The Second Law of Thermodynamics”, http://www.panspermia.org/seconlaw.htm, (accessed September 2005).
[185] Worster, 1995.
[186] Hay, 2002, pp.4-11.

human prosperity. Technological innovation was promoted in that model, in order to enlarge the capacity of human reason for progressive development. Accordingly, advances in science furthered this assumption regarding nature as the major supplier of industrial wealth.

Peter Hay's contemporaneous David Pepper puts that the Enlightenment tradition is considered as one of the means for current environmental problems in contemporary environmentalist ideologies, for the reason of its encouraging the reification of nature.[187] He informs that the environmentalist ideologies follow the disgrace of Romantics on the dominant Enlightenment outlook and their offer about a return to pre-industrial values. Pepper points out that the Romantics believed that urban areas are the major places for observing moral decadence and spiritual alienation. They claim to leave this subjugating vision, and to return to the ideals of pre-industrial past that saw humans dependent on nature. According to Romantics, as Pepper puts, cities displayed the "failure of *laissez-faire* liberalism's philosophy that a perfect society could be attained by essentially permitting people to follow their self-interest".[188] They believed that pursuing of material needs and attaining an individualistic manner both divorced humans from their organic roots to the land and devalued the beauty inherent in nature. They claimed to recover the loss of ethical stance towards nature through developing an arcadian vision, which is, according to Worster, "advocated a simple, humble life for man with the aim of restoring him to a peaceful coexistence with other organisms".[189]

It is understood that the arcadian outlook seeks a primitive order out of the flux of urban consumerism locating nature to a reified position. It sought, as Worster puts, for "a holistic and integrated perception and put emphasis on interdependence and relatedness in nature".[190] The followers of this approach tried to recapture his spiritual and primitive well-being by spending time in the country. As Worster puts, the apprehension of wild nature were believed to help "the resurgence of the pagan

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[187] Pepper, 1996, p. 124.
[188] Pepper, p. 189.
[189] Worster, 1995, p. 2.
[190] Worster, p. 82.

outlook towards nature"[191] being lost in the urban disorder. Accordingly, Pepper mentions that the Romantic outlook towards nature built up the philosophical foundations of the environmentalist ideology of "ecocentrism", seeking moral and spiritual advancement against the Western exploitative attitude, which found its peak in the industrial society.[192]

As Worster informs us, the influence of arcadian and imperial attitude in scientific ecology continued in the post-war era as a confusing mixture, because of the ambiguity in the scientific assumptions on planetary survival.[193] He puts that the vagueness began with Odum's declarations on the need for organic holism based on technological know-how. As a reminder, Odum emphasized that the planet earth is sick because of the human ambition for positive feedback and the cure lies in restructuring interrelations with nature through environmental management. Worster argues that Odums' ecology supported "the old dream of the conquest of earth, now ironically sought in the name of environmentalism".[194] As mentioned earlier, Odum shared his scientific vision with society by dedicating the last part of the book *Fundamentals,* to the ideas on socio-political reconstruction. For instance, he claimed town-country interaction, which is, as Pepper puts, one of the canons of the Romantic movement.[195] In the same part of the book, he reiterated the idea of technological control over environmental issues, alongside his arcadian idealism. For instance, he claimed the development of waste management centers in the cities. Or he mentioned about the endowment of a "spaceship ethic" for every citizen, which is based on the amalgamation of economic reasoning with space technology.

According to Worster, the mixture of technocrat and arcadian ideas continued in James Lovelock's Gaia theory, which includes "the breathtaking impact of the newest technology, the most up-to-date science, yet paradoxically resonated with the

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[191] Worster, p. 81.
[192] Pepper, 1996, p.13.
[193] Worster, 1995, pp. 342-433.
[194] Worster, p. 371.
[195] Odum, 1971, p. 16.

oldest pagan beliefs".[196] The name Gaia has Greek connotations coming form the ancient mother of earth. She is at all independent of human concerns for her self-organizing capability, while at the same time bound to human care and affection in order to sustain her equilibrium state. Ironically, as the physicist Fritjof Capra puts, the arcadian revival of Gaia was indeed because of space technology:

> Awareness of the earth as alive, which played an important role in our cultural past, was dramatically revived when astronauts were able, for the first time in human history, to look at our planet form outer space. Their perception of the planet in all its shining beauty- a blue and white globe floating in the deep darkness of space-moved them deeply and, as many of them have since declared, was a profound spiritual experience that forever changed their relationship to the earth. The magnificent photographs of the "Whole Earth" which these astronauts brought back became a powerful new symbol for the ecology movement and may well be the most significant result of the whole space program.[197]

Accordingly, the "confusing mixture" of imperial and arcadian paradigms exists in disequilibrium perspective as well. That issue can be understood when we observe the claims on the technological reconstruction under organic holism. As mentioned earlier, disequilibrium theories claim the possibility to reconstruct the whole system biologically, mechanically or chemically, even in positive feedback conditions. In this picture, any biological entity can be reconstructed with the aid of scientific know-how, even in the absence of environment. As the economist Jeremy Rifkin puts:

> The theory of dissipative structures provides a perfect rationalization for the age of bioengineering. It places a positive value on increased biological complexity and the continued reordering of living matter into new structures, which is what genetic engineering is really all about. With dissipative structures we move from viewing the world as an industrial machine to viewing it as an engineered organism.[198]

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[196] Worster, 1995, p. 378.
[197] Capra, 1983, p. 284.
[198] Jeremy Rifkin in Luis Fernandez Galliano, 2000, *Fire and Memory: On Architecture and Energy,* Cambridge and Massachusetts: The MIT Press, p. 115.

In this sense, we understand that although the mixture of the organic and the mechanic paradigms is always-at-present in ecology, the ways in which it appears are diverse. While the assumptions developed after the war approached the issue with an equilibrium perspective, the ones belonging endowed the disequilibrium view. Accordingly, the disequilibrium emphasis on biological engineering may legitimize every means of environmental intervention. Moreover, the view that biodiversity is not solely dependent on stability can develop misunderstandings that 'whatever you do, earth will reconstruct itself'. However, the geographer and environmental scientist Glenn Albrecht puts that the abundance of disturbed ecosystems may lead to catastrophe, rather than biodiversity:

> Too much emphasis on disturbance is likely to give free rein to the agents of change who see no harm in perturbing complex systems. Such agents might be tempted to argue that, since change causes complexity, why not continue or even accelerate the current pace of anthropogenic change. However, such a view must also take into account the importance of the preservation of information memories that are part of the order of life… Wholesale destruction of biodiversity, by removing "self-organization strategies at work", can lead to extinction cascades creating a situation where there are insufficient species available to allow for recolonization and, hence, regeneration of disturbed ecosystems. [199]

From above remarks, it is possible to conceive that a limit is also put to nature's interruption in the disequilibrium vision as well. In this view, it is assumed that living conditions should exist under homeostatic relations, while believing that this is not the only possibility for life. It is endowed with warnings about the importance of conserving interrelations of nature, while pursuing scientific and technological control. Here, it maintains the idea on the preservation of natural resources, while claiming environmental control under rationalist thinking. In this sense, organic and mechanic metaphors again find a place in ecological sciences, this time under the concept of disequilibrium.

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[199] Glenn Albrecht, 1997, *Organic Unity and the Limits of Conventional Justice*, Jun. 2003, http://www.arbld.unimelb.edu.au/envjust/papers/allpapers/albrecht/home.htm

CHAPTER 3

ON THE SYSTEMS ARCHITECTURE OF THE 60S

The biologist Ludwig von Bertalanffy, in his book entitled *General System Theory,* mentions that he theorized systems thinking in 1956 as a method of scientific research, after he discovered that the corresponding conceptions and laws appear in science when the relations between a certain totality and its constituting elements are concerned.[1] The general principle of this correspondence is outlined by Bertalanffy within the axiom "the whole is more than sum of the parts", meaning that:

> …constitutive characteristics are not explainable from the characteristics of isolated parts. If, however, we know the total of parts contained in a system and the relations between them, the behavior of the system may be derived from the behavior of the parts... [2]

Bertalanffy puts that the holistic outlook is an approach not only for the natural sciences, but also social sciences as well.[3] It is applicable to every phenomenon in general; whether it is physical, social, cultural or behavioral. It assumes that the development of a single entity can be studied if only the ways of its functioning with regard to other entities is captured within the entire scheme. He writes:

> Reality, in the modern conception, appears as a tremendous hierarchical order of organized entities, leading, in a superposition of many levels, from physical and chemical to biological and sociological systems. Unity of Science is granted…by the structural uniformities of the different levels of reality.[4]

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[1] Ludwig von Bertalanffy, 1968, *General System Theory: Foundations, Development, Applications*, New York: George Braziller, p. 33.
[2] Von Bertalanffy, p. 55.
[3] Von Bertalanffy, p. 81.
[4] Von Bertalanffy, p. 87.

Obviously, analyzing any kind of "system" or "complex set of interacting elements" scientifically necessitates a particular method. Bertalanffy puts that the recent discovery of the theories of open systems and of information gives us clues on how to explore the interrelations of an organization.[5] He informs us that both assumptions are developed with an account of cybernetics. The theories assume that interacting elements have a feedback system that alleviates their management via a controlled quantity, which eliminates irregular growth or development causing the elements to decay.

Indeed, when development is concerned, its negative counterpart, the inevitable phenomenon of degradation comes into being, due to the entropic condition of life. As mentioned in the preceding chapters, the theory of open systems, as formulated by Shrödinger, asserts that living entities pump out entropy through a network of metabolic relations being controlled by a feedback activity named as homeostasis. Bertalanffy mentions that Shrödinger's doctrine ended the dilemma between the law of thermodynamics and of evolution. The former declares that organisms inevitably decay due to entropy; while the latter informs that they grow and develop with regard to a selective mechanism. Hence, the theory of open systems, unite the two doctrines by putting forward that organisms fight with entropy owing to their metabolism. Moreover, the theory of information, as formulated by Shannon, assumes that knowledge is subject to entropy, too, therefore is in need of feedback control to evade information loss. These two doctrines suggest controlling any kind of development against decay and loss with regard to the constraints set before the process begins. They propose to investigate the phenomena through the cybernetic reasoning. Hence, systems thinking, when coupled with cybernetics, are the means to understand any kind of development, be it physical, social, economical or behavioral.

Hence, this holistic outlook of systems approach, quickly after it was theorized as a model of thinking in science, became a bias in architecture, especially for the ones who scrutinize the relations of architectural practice with the wider context of

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[5] Von Bertalanffy, p. 42.

physical, social and cultural reality. Systems thinking was conceived as a method of looking at architecture within the extensive set of problems that affected humanity, among which were the ones related with environmental deterioration. "The ecological problems are now so enormous that they are essentially cross-disciplinary" writes the systems theoretician James Boyce, in his article appeared in the magazine *Progressive Architecture* in 1969.[6] Hence, the ascending interest in architecture with regard to its environmental context created an appeal to systems theories, followed by investigations on how constituents behave in relation to the whole.

Bertalanffy announces that systems theory suggests the apprehension of a phenomenon with regard to the totality in which it belongs. Therefore, a particular system can only be the sub-system of a wider set of connections. Consequently, the architectural theoretician Barry Russell, who writes on the systems approach, emphasizes that if Bertalanffy doctrines are going to be of concern in architecture, then an architectural system should be considered as a sub-system within wider physical and cultural set of relations.[7] It should be understood as a complex organization which gains significance within the context in which it is situated. Russell delineates three levels of system in architecture, which are:

> 1. That of the building: a collection of materials and interlocking subsystems of technological bits. 2. The building and the people who use it: the interaction of the forms of the building, its use and administrative patterns. 3. The cultural context: Here we are concerned with the social place of the building and its users: together with the cultural symbolic meanings.[8]

From this remark, we understand that the architectural system is supposed to be developed with regard to the social setting in which it belongs. The contextual issues have to be thought upon alongside the technological configuration. Despite that assumption, Russell informs that when systems principles were of concern in

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[6] James B. Boyce, 1969, "What is the Systems Approach?" in *Progressive Architecture*, Vol. 50, p. 118.
[7] Barry Russell, 1981, *Building Systems, Industrialization and Architecture,* London: John Wiley & Sons, p. 684.
[8] Russell, pp. 691-692.

architecture, architects generally focus on the building itself, on the hardware systems that the building is composed of; alongside the "materials, components and subsystems and the way these relate together".[9] He writes: "The commonly understood notion of a building system centres around the idea of sets of dimensionally related components, largely factory produced, that fit together on site in a variety of ways to make buildings".[10] From these remarks, we understand that the technological configuration attracted more attention than the social and cultural setting in the systems architecture. The ways in which elements were combined with reference to the general constructional principle of a building were considered as more important.

James Boyce, in the *Progressive Architecture* journal, writes that systems approach provides a comprehensive way of looking at architecture for the ones who are stuck between the "technocratic" and "humanistic" models in the discipline.[11] On one side, as he informs us, there are the technocratic wing, which is represented by those who look at the world through the rationalist filter. According to this group, worldly problems should be solved solely through the improvement of technological know-how. Boyce mentions that this group is represented by those who have large-scaled architectural firms that offer high-tech solutions to the building construction. In these types of firms, the management consultants decide on the percentage of employee population. The design takes place according to the bill of quantities charts that reports the total construction cost. The industrial prefabrication and modular construction are favored in order to be fast and practical on site. On the other side, there are the humanists, who consider the worldly phenomena as the outcome of the social and political relations, and offer solutions related with the enhancement of dialogue between the social groups. The humanist side is represented by, as Boyce comments, "social activist architects dealing with community problems, often more involved with politics than plans".[12]

[9] Russell, p. 692.
[10] Russell, p. 683.
[11] Boyce, 1969, p. 118.
[12] Boyce, p. 118.

However, the promotion of systems thinking as an alternative to the rationalism the social activism resulted in the attempts to relate the model again with these twofold attitudes. The systems theoretician Boyce for instance, prefers to associate systems approach with rationalism.[13] He claims that rationalist-based perspective of the systems approach sets forth within the process of investigating the place of architecture in worldly affairs. Contrary to that, the systems theoretician Andrew Rabeneck, who edited the 1976 issue of *Architectural Design* magazine, puts that systems thinking provides a framework to approach environmental issues as a social task.[14] Systems analysis and research is helpful in relieving social problems. According to him, technology has only an instrumental role in the treatment of social ills. Despite his efforts to bring forward the social activist side of systems thinking, Rabeneck often refers to the training methods of the space engineering and military defense industry, which is more related with the use of technological know-how rather than with the social actions. As a result, it is possible to claim that systems view was associated with both the technicist and social activist views, despite the efforts of their challenging.

The systems theoretician Marvin Adelman, in his article appeared in the *Ekistics* journal of 1967, claims that systems research provides both technological and social solutions to the problem situation:[15]

> The system approach is sometimes touted as producing "best" solutions to problems, but it is better described more modestly as able to produce "demonstrably good" or defensible solutions. These solutions may take many forms. One is the design of some man-machine combination to carry out a needed set of operational or administrative tasks. Another is a budget, or plan for investing which is the usual result of a cost/benefit analysis. Still another is a set of policies resulting form a new understanding the problems, achieved through the sue of simulation or exercising, as in management games or military or civil defense command post exercises. Another kind of result might be in achieving a better understanding of available resources and how to use them, as in a field study, for example, of community

[13] Boyce, p.118.

[14] Andrew Rabeneck, 1976, "Whatever Happened to the Systems Approach?", in *Architectural Design*, vol.46, pp. 267-303.

[15] Marvin Adelman, 1967, "The Systems Approach: A Perspective", in *Ekistics,* v. 23, pp. 311-315.

> action agencies. Or, it could take the form of a design to build a new organizational or social process by providing incentives, jurisdictional arrangements and policies, as in the plan for an entire new city or for a revised city government structure in an existing community. [16]

As mentioned earlier, Barry Russell confirms that the technicist wing is dominant, rather than the social activist one in the systems architecture.[17] According to him, that condition causes a discrepancy between the General System Theory and its application in the discipline: "There is an important difference between what a theoretical stance can offer and those views which have so far passed for a system view in architectural usage".[18] Andrew Rabeneck mentions about the similar condition; he puts that systems approach is considered as the means to rationalize building hardware systems.[19] Moreover, he informs that the building software, which indicates the "design rules governing the procurement and assembly process which resulted in system building", is considered as a supporter in this rationalization process.[20] According to him, systems thinking helps in the production of theories for the further systematization of architectural practice. He puts that the outcomes of this kind of software production are the management models, cost and performance charts, activity reports, etc. Indeed, the promotion of software design alongside the hardware production in architecture is in parallel with the interest of systems scientists in the computerized management. Like systems scientists, systems architects believed that the building construction process should be supported by design theories, just like the computer is operated by software.

Furthermore, Rabaneck mentions that the comprehension of wider context of issues necessitates more than the hardware and the supporting software production; that a certain philosophy diverting architects to the holistic outlook is crucial. According to him, there are certain people in the discipline who help us to apprehend the theoretical side of systems approach. He puts that these people, among whom he includes Christopher Alexander and R. Buckminster Fuller, teach us how holistic

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[16] Adelman, p. 312.
[17] Russell, 1981, p. 684.
[18] Russell, p. 691.
[19] Rabeneck, 1976, p. 267.
[20] Rabeneck, p. 267.

outlook can be furthered as a model of architectural thinking. Andrew Rabeneck identifies them as having "the conceptual overview that focuses on some holistic phenomenon which can only be understood as a product of interaction among parts of a system."[21] He believes that those who are involved in the holistic philosophy consider systems approach as a means to tackle with social problems. For instance, he writes that Fuller's involvement with the systems approach is to liberate humanity from "inequalities that have historically divided humankind"[22]. Despite that, Fuller was a real believer in the power of technology and industrialized mode of production.

Indeed, whether in terms of making or philosophizing of architecture, there was an agreement upon the fact that systems approach offers methods to deal with complex and large-scaled problems, which were not only related with the dynamics of the discipline, but also with the worldly issues regarding ecology, economics and politics.[23] Consequently, the main problem was that systems approach being open to interpretation by everyone who would like to be involved in the systems thinking. Russell mentions about the difficulty of locating systems research to a definite set of principles for its being "too general and broad to yield an analysis", while believing that it "can posit alternatives by offering totally new ways of looking at things".[24] He gives the reason for the broadness; that according to him, architects confuse the idea of a system with being systematic. "To be systematic is to work methodically, according to plan", he writes, "whereas systemic describes those properties that are of the bodily system as a whole".[25] For instance the architect Nicholas Grimshaw declares in an interview published in the *Architectural Design* journal in which Rabeneck edited, that there is not anything special about systems approach.[26] According to him, any type of design has an alliance with systems view as it requires thinking about organizing things. Therefore, systems attitude meant diverse things to

[21] Rabeneck, p. 267.
[22] Rabeneck, p. 267.
[23] Boyce, 1969, p. 118.
[24] Russell, 1981, p. 685.
[25] Russell, p. 687.
[26] Nicholas Grimshaw, in Rabeneck (ed.) "Whatever Happened to the Systems Approach?", in *Architectural Design*, vol.46, p. 270.

diverse people. Some conceived it as a way of organizing complexity; others saw it as a method of seeking simplicity, and some thought it as just a way of producing architecture.

Marvin Adelman, in the *Ekistics* Journal of 1967, outlines the principles of systems analysis under five headings.[27] The first principle denotes to pursue investigation by organizing into a team of diverse disciplines, rather through an individual research. The second principle indicates to reevaluate the objectives with regard to the feedback response of the experts on the subject. The third one indicates to obtain help from computers in the process of arranging the collected data, which is, brainstorming practices, experiences, meeting notes etc. The fourth principle indicates to evaluate the collected data with regard to a certain theory or model. "One of the functions of the system approach", writes Adelman, "is to gather, and to the extent possible, organize the relevant theoretical work done in whichever academic disciplines (e.g. economics, sociology, engineering, psychology, anthropology, ecology) have something to say that related directly or indirectly to the subject."[28] Lastly, the fifth principle points to a research for a pragmatic reason. According to him, the result product should serve a function or accomplish a certain requirement. It should be used in the "world of practical affairs".[29] Adelman, at the end of the article, exemplifies the systems research followed in the aerospace and electronics industry, which he believes to be a sample for architects.

Indeed, the principles that Adelman described were also followed in the post-war ecological research and analysis. For instance, as seen in the previous chapter, individual research was not favored in systems ecology; thus, diverse team members come together for investigating the relations between members of an ecosystem. Then collected results were monitored through the aid of computer software. Like architects of the 60s, systems ecologists also favored models that belonged to the space engineering.

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[27] Adelman, 1967, pp. 311-318.
[28] Adelman, p. 312.
[29] Adelman, p. 313.

Indeed, systems ecology is mostly shaped by the rationalist agenda, like systems architecture. As it was mentioned in the second chapter, the ecological historian Worster sets forth how rationalism finds many forms in systems ecology, such as, the managerial attitude, functionalist reasoning, and the belief in the power of technology. Accordingly, in his book published in 1970, the architectural theoretician Benjamin Handler informs us that systems architecture mainly looks at the functionalist bias of the Modern period. He explains the reason for the dominancy of functionalist canon in the following:

> To explain the functioning or operation of buildings and components we must understand their parts and how they are connected. A building functions the way it does because its parts have certain attributes and because a given set of relationships among them. If these attributes and the way they are connected change, the function changes... It follows from these considerations that effectively to approach architecture in functional terms involves treating it as a system.[30]

In the functionalist model, every material element is supposed to serve a special function to enhance the integrity of the building system. According to Handler, this is why the term “operation” is regularly used in conjunction with the systems architecture. [31] Such use of the term appears in the definition “Operations Research”, indicating, as Handler informs us, the activity of controlling the functioning of an architectural system with regard to the objectives for which it is designed. The feedback control is a significant canon of systems research and analysis, and operations research is used to fulfill that requirement.

Consequently, Barry Russell claims that architects’ appeal to systems approach has more to do with their quest for efficiency, standardization or integration.[32] According to him, systems view projects the social bias towards domination and control over every phenomenon in general. Therefore, architects reflect this social desire of control. He writes:

[30] A. Benjamin Handler, 1970, *Systems Approach to Architecture*, New York: American Elsevier Publishing Company, Inc., p.14.
[31] Handler, p. 11.
[32] Russell, 1981, p. 698.

> Through all this we still find the idea of 'total design' present. For most architects those buildings which have a consistency and coherence running through from the idea to the smallest detail are those to be admired, and indeed there is something impressive about such an act of will…The vision of a total architecture of standardization, of industrialized parts is one of these models. Systems terminology would characterize this as the creation of systems with a considerable degree of closure. Within the boundaries of such systems there is a degree of control, the whole can be understood. Similarly the philosophy can be seen at work in single buildings. Often those buildings that are particularly good at integrating all the technological aspects of design also exhibit a large degree of control over their internal environment.[33]

As information, functionalism emerged in parallel with the social fascination with technological development, which was accelerated with the industrial revolution. It presupposes the complementary elements of a totality to be primarily operational like a mechanical apparatus. The architectural counterpart of functionalist doctrine assumes that the formal composition influences the functioning of a building system; just like a set of connections between mechanical sub-elements determine the operation of a machine. The functionalist assumption in this way is closely linked with the principles of systems thinking. The quest of systems architects for efficiency was the reason of their commitment to the functionalist ideology.

Accordingly, Handler puts that there are diverse tendencies in conjunction with functionalism, which one of them is "organicism".[34] As he puts, the organic doctrine appears when the "form and function are identical" principle comes forward in the modern architectural design.[35] The principle indicates that the form and function bear similar importance and closely related in spatial configuration. It assumes the futility of both developing form without identifying which purpose it serves and determining function without knowing its shape. Handler writes:

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[33] Russell, p. 703.
[34] Handler, 1970, p. 14.
[35] Handler, p. 14.

> Form is an interrelation of parts, all acting, interacting, and reacting together. The parts of a building are not related merely as successive additions or in simple juxtaposition. Each is related to and determined by all the others. They are all subordinate to a dominant tendency, to a way of functioning together which makes the totality more than a simple agglomeration.[36]

The mutual interactions between elements of a whole are presupposed in the systems approach as well. The relations between formal configurations and functional attributes are considered as significant factors on the operation of the total building system. Hence, systems approach comes forward whenever there is a need of investigation about the relationship between the parts and the whole; whether it is practiced in terms of spatial configuration or material composition.

As a result, systems approach was dominated by the technicist agenda rather than the social activist one in the period in which it was first appropriated into the realm of architecture. The building was assumed as a self-sufficient entity working like a machine and behaving like an organism. As mentioned in the previous chapter, the amalgamation of the mechanic and the organic was also observed in the systems ecology; that the earth was also supposed to work like a machine and to behave like an organism, while being in the process of self-regulation.

3.1. The Technicist Perspective: Building as an Open System

This chapter is about the frame of thinking that came along with the systems approach in the discipline of architecture, after the period that systems theory was first put into place in science. Then, the question is, how was systems view considered in architecture in the period of its appropriation? Systems approach was pondered in architecture like the way it was pondered in the systems theory itself; with regard to the theories of open systems and of information. When the rationalist

[36] Handler, p. 10.

paradigms were of concern in architecture, systems principles appeared in relation with the theory of open systems. The building system was considered as a self-sufficient machine with its regulatory system inside; being subject to energy exchange with the nearby. For instance, the systems theoretician Benjamin Handler, writes that a building behaves just like a living organism; it is interrelated with its environment in energetic terms:

> Using this kind of approach, an analogy may be drawn between a living organism and a building. The former has been treated as a system possessing organization and wholeness, not a closed but an open system which maintains a constant state amidst the ever changing matter and energy entering it, and which, influenced by and influencing, its environment achieves a state of dynamic equilibrium with it. Such a description is also applicable to a building. Here, we have a structure on a site and all the components of both, possessing visual, atmospheric, acoustical, and other properties, designed to operate in a given manner in the light of given sets of activities and objectives. The properties, operations, and activities retain their identity while the people and energy inputs entering the building and site keep changing. This totality adjusts to changes that occur in its surroundings, and these in turn are influenced by its existence and operation. Pathological conditions exist when the objectives cannot be achieved either because of some fault in the internal workings of the system or through failure in adjustment between it and the environment.[37]

In the above remark, Handler depicts the building by conforming to the technocratic frame of thinking: a self-sufficient entity working like a machine and behaving like an organism. The building is supposed to have an internal mechanism with its inputs, outputs and a feedback scheme for its conformity with the outside environmental conditions. Moreover, he puts that industrialization and standardization are the agents to arrive at the energy efficient building systems.[38] The implantation of mechanical equipment is to develop the interrelations of building with the environment in energy terms.

However, the green architectural theoretician Dean Hawkes mentions in his book entitled *The Environmental Tradition,* that in the 60s, the mechanical means of

[37] Handler, p. 22.
[38] Handler, p. 23.

energy exchange was not achieved in favor of environmental equilibrium, but in favor of human comfort.[39] In this scheme, building was an open system that is subject to exchange in the form of taking in the useful energy and pumping out the harmful one to the environment. Hence, the building equilibrium was controlled via the human performance criteria, rather than the environmental performance. Accordingly, Hawkes mentions about the shift of emphasis in architecture in the recent years, from the design for human well-being to the design for environmental well-being. As he puts, the idea of self-sufficient building for human advantage is altered due to the ascending awareness of architects on the side of environmental appropriateness. Contemporary architects try to defy the damage that was emerged due to the wide use of active mechanical systems with the implantation of passive ones. Passive systems utilize energy sources which are harmless to the environment, such as sun radiation, wind power, plant waste, geothermal sources etc.

Thus, the systems approach was compelling for the architects of the 60s in the provision of inside comfort, rather than one of the outside. The building was considered in equilibrium condition if only it corresponded to the thermostatic conditions determined by the users. Mechanical systems supported this steady-state building environment. In this sense, Russell’s aforementioned analogy between a building and an organism hardly supports the equilibrium idea as put forward in the theory of open systems. As a result, a building was considered as an open system in the 60s, because it was supposed to exchange energy with the environment in order to protect its own integrated mechanism in the advantage of users. Hence, the systems construction processes seem to pave way to the environmental deterioration at that era, despite that their creators used abundant terminology of ecosystem science. Unlike buildings, ecosystems remain in a steady state not only for themselves, but for the ecosystem which they belong to.

Consequently, Hawkes argues in the same book that the value given to the self-steady environment set up the foundations of the growing concern with

[39] Dean Hawkes, 1996, *The Environmental Tradition*, London: E and FN Spon, pp. 11-15.

environmental issues among architects at the same time, while it rendered an increase in the energy consumption of buildings at that period.[40] According to him, the 60s apprehension for the mechanically-produced cybernetic environment constitutes the basis for today's environmentally-appropriate architecture. Hawkes claims that environmental technologies in modern buildings became a subject-matter the first time due to the influence of two architectural theoreticians in the 60s. One of them was Reyner Banham. In his book entitled *The Architecture of the Well Tempered Environment* published in 1969, Banham mentions that architecture is no longer composed of autonomous structures in which the materials are assembled upon.[41] Rather, it is an engineered environment providing climate for human activities. Hawkes puts that Banham's arguments were the means to later discussions about how to protect environment while controlling the indoor climate for human comfort.

The other one whom Hawkes gave place was Banham's contemporaneous, Victor Olgyay. In his book entitled *Design with Climate,* Olgyay furthered the concept of building as a self-regulating system by putting that the building should also correspond to the environmental energy system alongside the internal one.[42] He argues that engineered structures should not only provide human comfort, but also find ways to act in accordance with the ecological environment. In the book, he displays the diverse means of arranging building elements with an emphasis on conformity with the climatic conditions of a particular setting. His assumptions provided a typological source for the ones who investigate on the climatic comfort in those years. Hawkes mentions that Olgyay's climate-oriented building typologies, coupled with Banham's studies on mechanical means of comfort, provide a basis for the environmentally-conscious architecture of today.

Architectural typologies give us clues on the diverse means of ordering building elements. Sometimes they are the agents of experimentation to arrive at a formal

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[40] Hawkes, p. 12.

[41] Reyner Banaham, 1969, *Architecture of the Well-Tempered Environment,* Chicago: University of Chicago Press.

[42] Victor Olgyay, 1963, *Design with Climate: A Bioclimatic Approach to Architectural Regionalism,* New York: John Wiley & Sons.

solution for a particular objective. In the case of green architecture, Hawkes mentions that typologies help to experiment on the proper means of integrating engineered mechanisms into the built forms in order to arrive at the self-regulatory building units. He suggests obtaining help from the equilibrium perspective provided by systems approach in order to control the relations of engineered elements with the built forms. His arguments give evidence on the emphasis put on the single building unit as the object of environmental control, rather than on the interrelations with the building and its ecological surrounding. The bioclimatic building typologies are the subject of interest today for those aside from Dean Hawkes, seeking for both environmental consciousness and human comfort at the same time, to be argued in the subsequent chapter.

With a reference to those who were involved with the subject-matter, we learn that systems architecture was mostly dominated by a technicist agenda after the 60s. The technicists focused on the elementary and engineered composition inside the building, rather on the building in its social, cultural or environmental context. In conformance to the picture provided by the theory of open systems, they considered the building as a single entity with a regulatory mechanism inside. Moreover, they gave importance to the mechanical configuration for their providing a control mechanism for human comfort. The mechanical implantation was assumed to be in congruence with the general structural composition, as stated by the systems principles. Furthermore, systems architects considered that efficient architectural production should be achieved via the help of software, which are the theories on the ways to develop cybernetic means of design and construction. The following paragraphs are reserved for those who prefer to deal with software.

3.1.1. The Methods of Software Production under Rationalism

This section is about those who developed design theories with the help of systems approach. Obviously, we encounter an extensive use of systems scientific terminology in the writings on software production, such as, “steady state”, “self-regulation”, “feedback”, “input-output” etc. In the light of those who developed writings on the subject-matter, it is possible to claim that two principles dominated software production in the process of systems appropriation in architecture. The first one was the consideration of the design process as a cybernetic activity[43]. Here, architectural activities were divided into sub-processes in which feedback mechanisms are put into place. The second one was the management of design process with the help of computer software.

Indeed, one of the figures being involved with the first principle of software production was James Boyce. In his article entitled *What is the Systems Approach*, published in 1969, Boyce discusses about the role of feedback in architectural design.[44] He puts forward the ways of increasing the efficiency of architectural activity through a steady-state design development. He emphasizes that systems approach provides a frame of thinking to those involved with the cybernetic design process. He argues that the success or failure of large-scale projects depend on the proper design management. He outlines three different methods of managing the design. The first method is treating the design as a “sequential system”. Here, the design sub-processes, which are “schematic design, design development, construction documents and construction administration”, develop in a sequential order.[45] They are unalterable in the later phases. Therefore, the “sequential system” is applicable to the small-scaled projects rather than the large-scaled ones. The second method is treating the design as a “cyclic system”. Here, every sub-process is altered as the result of the user performance criteria. The designer gets feedback from the user before the design is completed. The third method, as Boyce puts, is treating the design as an “evolutionary system”. This alternative is sufficient for the participatory

[43] The definition of cybernetics is written in the web site entitled *Principia Cybernetica* as the following: “Cybernetics, deriving from the Greek word for steersman (*kybernetes*), was first introduced by the mathematician Wiener, as the science of communication and control in the animal and the machine (to which we now might add: in society and in individual human beings). It grew out of Shannon's information theory, which was designed to optimize the transfer of information through communication channels (e.g. telephone lines), and the feedback concept used in engineering control systems.”

[44] Boyce, 1969, pp. 119-121.

[45] Boyce, pp. 119-121.

designs or the large-scale projects. Here, there is not any fixed performance criteria. The design sub-processes can be altered with regard to the feedback response that may come from any social group, such as, the user, the design team, the administrative regulation etc.

Hence, Boyce's article reflects the equilibrium view, which was a prevalent approach among systems thinkers in those years. The design is considered in a steady-state condition as it is controlled via agents, such as users, social groups, environment etc. Moreover, the impact of the socio-cultural mentality of this period can be observed in the article. He uses ecological terminologies to explain a phenomenon. For instance, he assumes that every design sub-processes has internal relations among themselves, resembling those of parent-sibling of the animal community.[46] His interest in the ecological literature might be because of social influences. Ecology became a subject of interest in the 60s due to the public concern with environmental issues. Furthermore, in the article, he mentions about the ways in which the departments of aerospace engineering evaluate design within a corporate environment. His exemplification of the space engineering research throughout the article reflects the social concern with the space programs at that era.

The other figure interested in the architectural software was Benjamin Handler. In his book entitled *Systems Approach to Architecture* published in 1970, Handler argues on the efficient means of architectural practice.[47] Unlike Boyce who puts emphasis solely on the design, Handler pays attention to every means of architectural activity. He puts that architecture is comprised of design, construction, maintenance and bionomic processes, which indicate human needs and social objectives. He considers each architectural process as a mechanism that has its own input data, process activity and output "objectives toward which the totality is directed".[48] He puts that each process operates through feedback control. The input data and the process activity are controlled via the output objectives. Here, Handler supports a cybernetic

[46] Boyce, p. 121.
[47] Handler, 1970, pp. 35-50.
[48] Handler, p. 36.

perspective similar with Boyce's evolutionary feedback, in which the architectural process is subject to alteration whenever there is a response. According to him, there are three agendas of control. The first is the human needs as well as the social and symbolic objectives. The second is the environmental objectives, such as the physical and climatic conditions. The third is the economical objectives, which are budget, technological and institutional constraints. Handler proposes a system in which there are relations between each processes, such that the control criteria can also be the input or output, because he believes that systems thinking is embedded with complex network of relations. (Fig. 3.1)

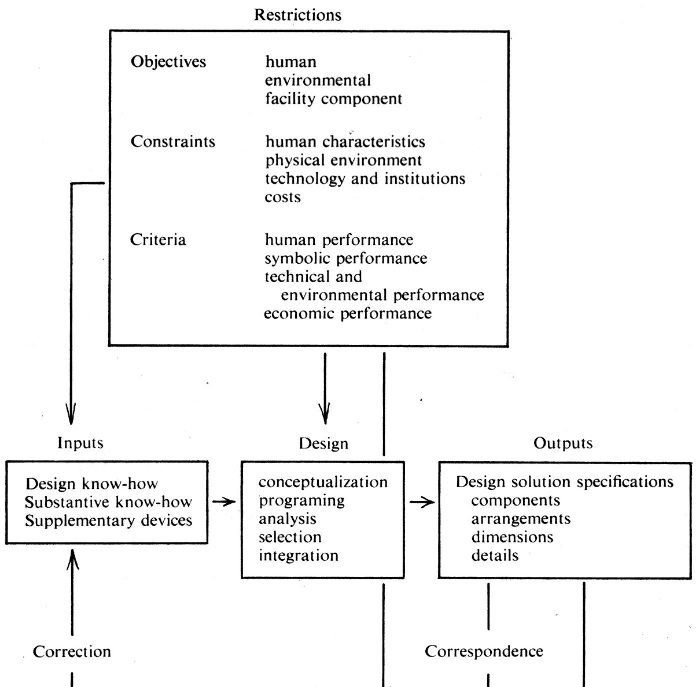

Fig. 3.1. Handler's diagram of design subsystem.
Source: A. Benjamin Handler, 1970, *Systems Approach to Architecture*, New York: American Elsevier Publishing Company, Inc, p. 42.

Handler outlines the input, process activities and outputs of every architectural process. Beginning with the design process, the input is comprised of technical know-how and expert knowledge. The process consists of the activities of conceptualization, programming, analysis, selection and integration. "Conceptualization" is the development of an overall view. It is open to reevaluation in order to lead to a possible solution. "Programming" is the survey of human requirements. "Analysis" is the investigation of the site, functions and environmental conditions. "Selection" is the decision making on the physical components, such as structure, materials, mechanical systems, site and layout. "Integration" is to end up in a solution. He informs that the output of the design process is the input of the following construction process.

According to Handler, another process is construction. Like the other processes, construction is composed of input data, process and output. The input data is design knowledge, land, labor, materials, capital and design specifications. The process activities are the arrangement of construction site, the management of materials and construction equipment. The output is the building itself. It is at the same time the input of the subsequent process, which is facility operation or the building maintenance.

Consequently, the third one, according to Handler, is the maintenance process that begins after the building is completed. The input data are the energy sources and labor needed to operate and sustain the building. The output is the physical environment with its thermal, acoustical, spatial and visual characteristics. Handler mentions that as long as a building is completed, it becomes a facility being ready for utilization and management; hence as he suggests, "it is operational by its very existence".[49] In this manner, as he puts, the building becomes a "machine"; its mechanical substitute becomes of concern rather than its aesthetic attributes. He writes: "To continue in operation, it has to be kept in running order: maintained and

[49] Handler, p. 46.

kept in repair, cleaned, its parts and components replaced from time to time".[50] Note that the similar viewpoint also exists in the systems ecology. As mentioned in the previous chapter, ecologists compared our planetary system to a machine that is open to maintenance and repair. Therefore, it seems that the socio-cultural emphasis put on the environmental issues affected Handler as well. The building is depicted as a machine that is in need of maintenance to maintain its steady-state.

So far, it was mentioned about one of the systems principles considered in the architectural software production, which is the feedback control. The second principle is the computerized management. It is one of the tenets in the systems ecology as well; that scientists often referred to computers to apprehend the general picture of ecosystems. Accordingly, the book entitled *Models and Systems in Architecture and Building*, which is published in 1973, consists of articles that interrogate the place of computers in architectural design.[51] One of them, entitled "Computer Representations of Architectural Problems", belongs to Janet Tomlinson.[52] In the article, she argues on the data arrangement in the computer media. She displays the ways in which the data can be modified with regard to the revisions by those who evaluate the design. According to her, the most convenient programs allowing that type of modification are Fortran and Cobol. She puts that the while Fortran is programmed in a box-like arrangement, Cobol is programmed in a tree-like arrangements with branches and leaves (Fig.3.2).

[50] Handler, p. 46.
[51] Dean Hawkes (ed.), 1973, *Models and Systems in Architecture and Building,* Lancaster: The Construction Press Ltd.
[52] Janet Tomlinson, 1973, in Dean Hawkes (ed.), "Computer Representations of Architectural Problems", *Models and Systems in Architecture and Building,* Lancaster: The Construction Press Ltd., pp. 60-70.

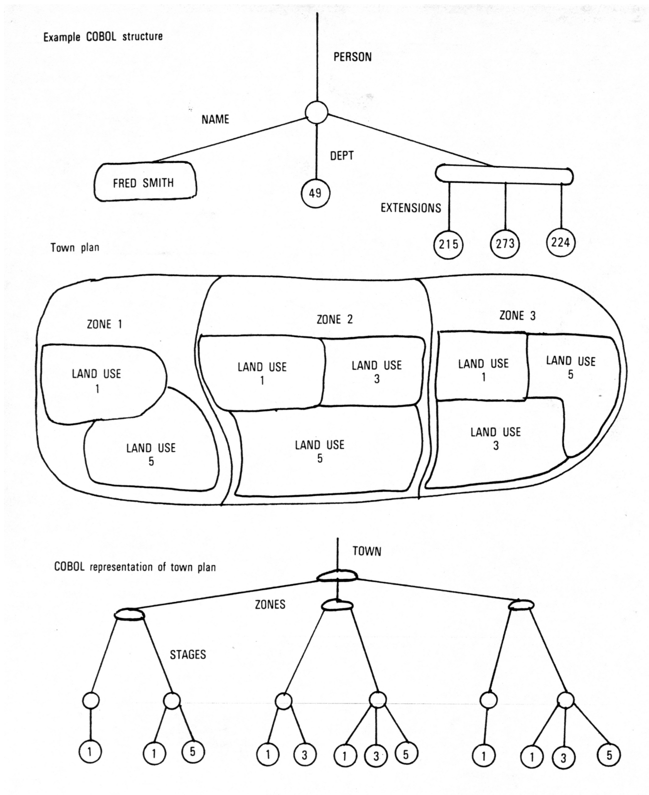

Fig. 3.2. Tomlinson's diagram of COBOL structure.
Source: Janet Tomlinson, 1973, in Dean Hawkes (ed.), "Computer Representations of Architectural Problems", *Models and Systems in Architecture and Building*. Lancaster: The Construction Press Ltd., p.61.

In the article, Tomlinson seems to favor the tree-like arrangement of the design issues on the computer. As a reminder, the tree-like figures are frequently sampled by those who deal with the systems approach. For instance, the systems scientist Fritjof Capra claims in his book published in 1982, that in the systems approach, tree-like structures are the best means to represent the relations of elements within a totality. The tree represents the general framework, whereas the branches and leaves represent the sub-elements connected to this general framework. (Fig.3.3). Tomlinson's article depicts that computer representation of architectural problems conforms to the picture provided by the systems approach, in which every problem definition within a particular process affects the subsequent processes.

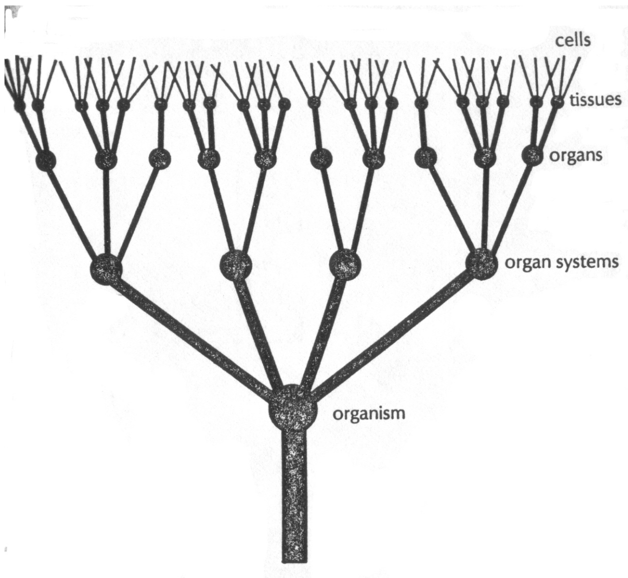

Fig. 3.3. Capra's picture of systems framework in ecology.
Source: Fritjof Capra, 1983, The Turning Point: Science, Society, and the Rising Culture. New York: Bantam Books, p. 281.

The other article that appeared in the same book regarding the second principle belongs to Keith Ray. In his article entitled "Activity Modeling in Hospitals", he argues on hospital building management on the computer media.[53] He shows how to put order to the patterns of circulation and daily activities in hospitals with the aid of computer programs. A reminder should be put here that systems researchers involving with the rationalization of architectural practice prefer mostly to deal with large-scaled types in which complex activities take place, such as hospitals or school buildings. In the article, Ray mentions that the management structure of hospitals has a determining role in the creation of activity patterns. He suggests diverse techniques of collecting data. One of them is ordering the flow patterns in a tree-like structure as suggested in the Cobol (Fig.3.4). Obviously, his article was embedded with well-

[53] Keith Ray, 1973, "Activity Modeling in Hospitals", in Dean Hawkes (ed.), *Models and Systems in Architecture and Building,* Lancaster: The Construction Press Ltd., pp. 113-134.

known terminologies from systems outlook, such as input and output etc., and his outlining of the article clearly displays the situation:

> The primary concern has been to establish how the activity patterns are influences both by the operational policies and by the physical layout of the hospital, and the aim has been to develop a model which takes these policies and the layout as input and which may be used to make predictions about what each person is doing and what his location is throughout his working hours.[54]

Another article that appeared in the book regarding the subject-matter belongs to Neil Milbank. In his article, Milbank argues about how computer software evaluates the environmental performance beforehand the building is completed.[55] Thermal programs in particular, develop a model of a building on the computer screen in which the impact of the environment is displayed. According to him, model development is functional in determining the relations of the built form with the natural environment. He exemplifies how a particular computer program calculates thermal performance with regard to human comfort. One of them is "the finite difference technique". Here, the program slices the building into sections and calculate the total performance via the sum of those of every building section. Another method is the "harmonic solution". Here, the program displays the energy consumption of the building under the assumption that it has reached "the stable or equilibrium state for some given cycle of weather and usage."[56] He writes: "In a 'steady-state heat loss' equation, heat gains must equal heat losses, unless a building has an artificial cooling system."[57]

As a result, it is plausible to claim that the software production was determined by an equilibrium perspective in the years of systems appropriation in architecture. It was considered to be essential in the management of design process and the arrangement of the material elements of built form. In these software models, the design is

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[54] Ray, p. 113.
[55] Neil Milbank, 1973, in Dean Hawkes (ed.), *Models and Systems in Architecture and Building,* Lancaster: The Construction Press Ltd., pp. 83-90.
[56] Milbank, p. 85.
[57] Milbank, p. 88.

considered in a steady-state condition as it is controlled via the agents of control, such as social context, environment etc. The computer software is developed to maintain the building equilibrium. As mentioned earlier, hardware production was of concern alongside the software in the systems architecture. The following section introduces the 60s hardware development through systems research and analysis.

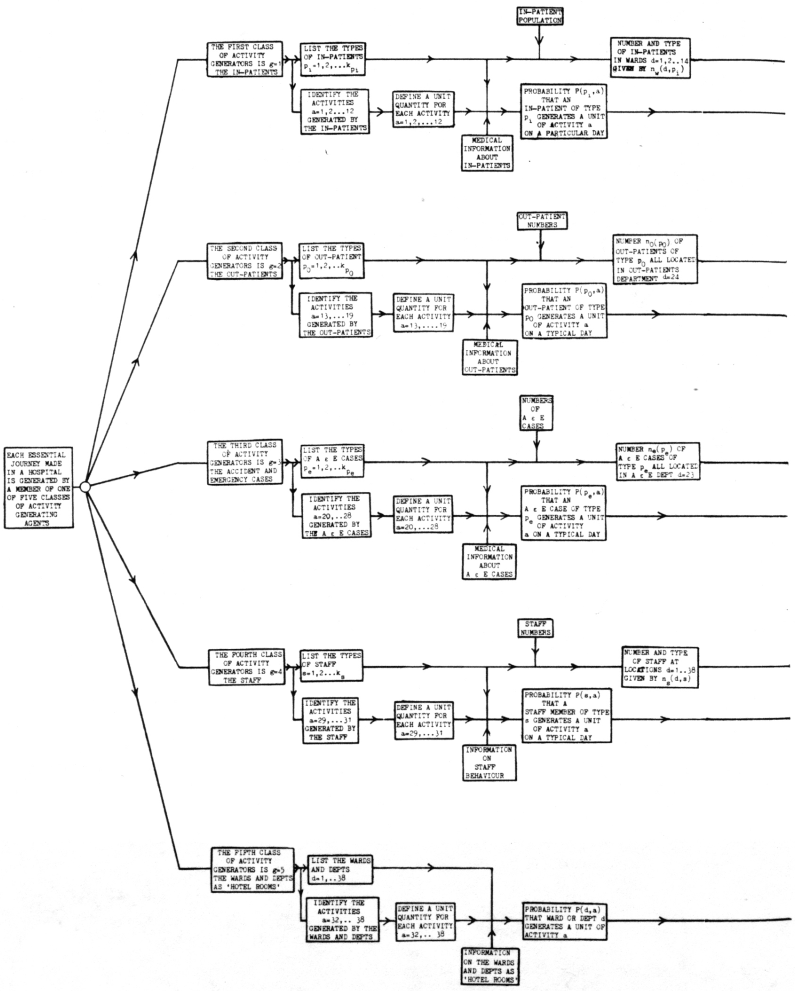

Fig. 3.4. Keith Ray's systematization of circulation patterns in a hospital.
Source: Keith Ray, 1973, "Activity Modeling in Hospitals", in Dean Hawkes (ed.), *Models and Systems in Architecture and Building,* Lancaster: The Construction Press Ltd., p. 115.

3.1.2. The Cybernetics of Hardware Production

This section is reserved for the architect Ezra Ehrenkrantz, who was well-known in the architectural arena through his methods of hardware design and construction under the framework provided by the systems approach. His focus of attention was mainly the school buildings that drove him to establish a design team for that specific purpose. The "School Construction Systems Development" in particular, was comprised of the members from diverse professions. The team helped Ehrenkrantz to practice architecture by using technology and know-how. For a decade or so, the team produced comprehensive building elements for the schools. Ehrenkrantz was distinguished in the discipline because of his involvement with both software and hardware systems at the same time, when he was commissioned for a project. "Our conclusion is that we must take into account not only hardware systems that go into buildings, but the software as well", Ehrenkrantz writes in one of his articles.[58] In the same article, he identifies the software as "the marketing and the management techniques that are needed to order the entire process".[59]

In his book entitled *Building Systems, Industrialization, and Architecture*, Barry Russell outlined the usual procedure that SCSD followed.[60] After being commissioned for a school project, the team first spotted the school districts in a certain region. The members investigated on what type of school was located in which region, how they were assembled and how they could function in the future. Then they organized the collected results into charts. They designed their hardware materials accordingly. During the design process, they put emphasis on the integration of their material components with the structural, mechanical, electrical and lightning systems. After that, they contacted with the local firms that were interested in the production and marketing of their products. Accordingly, they

[58] Ezra Ehrenkrantz, 1971, "Systems Building", in *Ekistics*, v. 31, p. 167.
[59] Ehrenkrantz, 1971, p. 167.
[60] The information on the SCSD methods of research was borrowed from Russell, *Building Systems, Industrialization, and Architecture*, pp. 529-551.

prepared bill of quantities charts displaying the unit price of these elements. After the hardware units were marketed, then comes the construction phase. Tender documents were prepared and the constructor firms established the schools with Ehrenkratz's hardware.

The SCSD team designed the Stanford Educational Facilities Laboratories, which was financed by the Ford Foundation, by pursuing the aforementioned process in 1967. The building has modularly arranged spaces that are separated by partition units. The spaces are enlarged and contracted by following the grid plan. As flexibility was the purpose, the frequent repetition of load-bearing elements was not preferred. Therefore, the steel columns span the entire volume. Environmental control is achieved through the mechanical ventilation. Here, the SCSD team took into account not only the construction, but also the maintenance processes. After the school staff began to use the building, the contractors submitted a report on the performance of the hardware. The components, which did not meet the user requirements, were replaced by the new ones. Furthermore, the additional ones are mounted to enhance environmental quality. The monitoring process continued even after the construction was completed. User evaluation reports were provided as a means for the feedback control. Additional precautions were taken when a defect was observed. That sustained the proper performance of the building. Indeed, as Ehrenkrantz informed us, not only the performance criteria, but also time and cost are the basics of feedback control in building construction:

> We are looking at an ability to get a building constructed for the initial projected cost, to have it open at the planned time and to have it perform, in terms of characteristics of performance quality within the building, as predicted or projected initially in the programme brief. [61]

[61] Ezra Ehrenkrantz, 1975, "Cost/Performance: The Key to a Building Systems Approach", in Dean Hawkes (ed.), *Models and Systems in Architecture and Building,* Lancaster: The Construction Press Ltd., p. 177.

Thus, with the help of systems research and analysis, SCSD group offered a comprehensive process from the design to the construction and maintenance. The SCSD team's blow-up axonometric drawings that display the systemic arrangement of industrialized hardware are an educative tool in the schools of architecture even today (Fig.3.5). As a result, the team's work is the indication that hardware production requires a comprehensive interdisciplinary analysis and research beforehand the design. "The problem is to balance resources and requirements before we begin the design", told Ehrenkrantz, "then a good designer will design a handsome building; a mediocre designer will do a mediocre building; but at least they will be able to design buildings that function".[62] Therefore, pragmatic concerns step forward in their designs rather than the aesthetic ones.

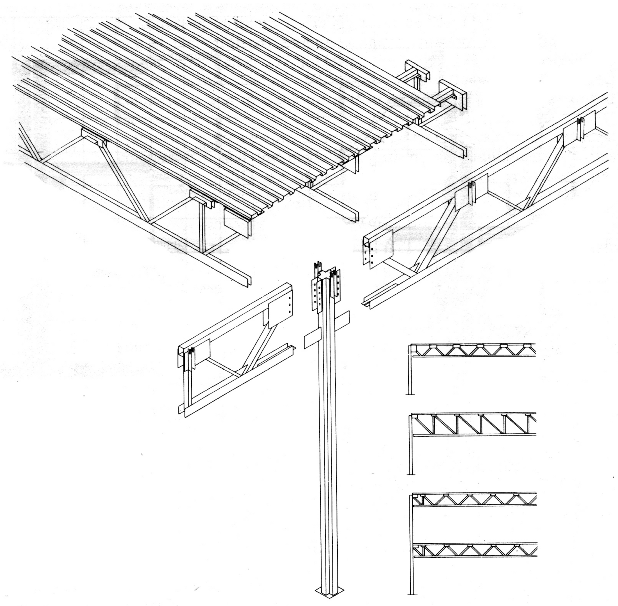

Fig. 3.5. Ehrenkrantz's blow up axonometry of his school systems.
Source: Russell, Barry. 1981. Building Systems, Industrialization and Architecture. London: John Wiley & Sons, p. 541.

[62] Ehrenkrantz, 1975, p. 178.

Such systems analysis techniques, which were developed after the 60s, are helpful in the environmentally-appropriate building construction and maintenance today. The total energy spent during manufacture, construction and transportation of materials, in order words, the total embodied energy is calculated by the computer aid to decrease the energy spent during the making of buildings. Demountable materials are used for both their replacement in case of damage and their reuse in another context. Modular techniques and standardized elements are preferred in order to facilitate an organized assembly and demount. Performance charts are created to understand the functioning of construction equipment and achieve their maintenance and control in the general organizational framework. After the building is put into use, the energy inputs and outputs are entirely monitored in order to reduce the emitting of harmful matter to the natural environment. Hence, feedback controls are significant for ecological design and construction, because every building element is determinant in changing the total organization negatively or positively.

As it was written in the earlier paragraphs, in *the Architectural Design* journal of 1967, the editor Rabeneck points out that systems thinking requires more than hardware and its supporting software production. He mentions that systems architecture should be considered as a kind of social task; and it can be achieved when a certain philosophy, which orients architects to the holistic outlook, is developed. Hence, the following paragraphs are about the architect Buckminster Fuller, who is among the figures that Rabeneck announces as dealing with the philosophy of systems architecture. With his emphasis on the industrial and technological development for human survival, Fuller is the representative of the technicist branch of the systems approach. His significance lied in his providing a coherent systems position in architecture, while his contemporaneous followed the subject matter as a temporary social flow. His assumptions are still utilized today in green architectural debate, which will be concern of the following chapter.

3.1.3. Buckminster Fuller: From Systems Ecology to Geodesic Structures

The disastrous effects of the Second World War constituted the grounds for an ascending public curiosity about the future condition of earth for the continued existence of humanity. Indeed, systems ecologists became the agents of recourse regarding human remedial due to their expertise in the overall look on environment. Bringing forth the social participation on environmental matters, it was obvious that sooner or later systems thinking was to become the interest of other disciplines, including architecture. Buckminster Fuller was one of the figures who introduced systems approach to architecture. He began to be interested in architecture after he established a company with his architect father-in-law.[63] In fact, architecture was only one of the fields that attracted his attention. He was involved with many professions although he did not receive a university degree from any of them. His creativity gave way to diverse inventions and ideas that were in fact the subject of different fields. Fuller's significance in the architectural arena was his special way of thinking that is based on the systems approach. The following statement reveals his interest in the systems theory:

> One of the modern tools of high intellectual advantage is the development of what is called general systems theory. Employing it we begin to think of the largest and most comprehensive systems, and try to do it scientifically. We start by inventorying all the important, known variables that are operative in the problem. But if we don't really know how big "big" is, we may not start big enough, and are thus likely to leave unknown, but critical variables outside the system which will continue to plague us. Interaction of the unknown variables inside and outside the arbitrarily chosen limits of the system is probably going to generate misleading or outrightly wrong answers. If we are to be effective, we are going to have to think in both the biggest and most minutely-incisive ways permitted by intellect and by the information thus far won through experience. [64]

[63] The details of Fuller's life can be read in 1983, *Inventions: the Patented Works of Richard Buckminster Fuller,* New York: St. Martin's Press.

[64] R. Buckminster Fuller, 1969, *Operating Manual for Spaceship Earth,* Carbondale: Southern Illinois University Press, p. 60.

The above remark shows that systems thinking helped Fuller not only see the big picture, but also the issue that every variable is connected to the others through an all-embracing network. Correspondingly, the expression he used for the interrelatedness of things was "synergy", the Greek word that means "working together".[65] In his book *Synergetics,* he defines the term as the "behavior of whole systems unpredicted by the separately observed behaviors of any of the system's separate parts or subassembly of the system's parts".[66] In the book, he exemplifies certain synergetic elements. One of them is steel, a metallic alloy, which has strength far greater than the strength of its components.[67] The working of the steel proves the dictum 'the whole is more than sum of its parts'.

According to Fuller, comprehensive thinking was the way through seeing the interdependence of every phenomenon. Hence, in his book *Operating Manual for Spaceship Earth,* he displays his disavowal against every means that distracts one from making an overall set-up of issues.[68] He writes about how he disliked the idea of "specialization" in the modern economic society, where every person is involved with a particular expertise without having a general idea about the thing of concern. As a reminder, the systems theorist Ludwig von Bertalanffy, in his book *General Systems Theory,* also criticizes specialization in the modern economic setting as well.[69] He renounces those who focus on the details, rather control the overall frame of work. According to Bertalanffy, one should not deal with parts before looking from the top-down. Consequently, Fuller's interest in the air transport vehicles was related with his appeal to the top-down outlook. Furthermore, he believed that architects and planners are more skilled in endowing a holistic outlook than other professions.[70] According to him, any researcher must "assume the role of planners

[65] The definition is found in the online Meriam Webster dictionary at the following website: http://www.m-w.com/
[66] R. Buckminster Fuller, 1975, in collaboration with E.J. Applewhite, *Synergetics: Explorations in the Geometry of Thinking*, New York: Macmillan Publishing Co. Inc., p. 3.
[67] Fuller, 1975, p. 7.
[68] Fuller, 1969, *Operating Manual,* p. 13.
[69] Von Bertalanffy, 1968, p.17.
[70] Fuller, 1969, *Operating Manual,* p. 59.

and begin to do the largest scale comprehensive thinking of which we are capable”.[71] The resulting statement displays his critical attitude against those who attain a “reductionistic” attitude against general set of issues:

> We begin by eschewing the role of specialists who deal only with parts. Becoming deliberately expansive instead of contractive, we ask, “How do we think in terms of wholes?” If it is true that the bigger the thinking becomes the more lastingly effective it is, we must ask, “How big can we think?”[72]

How big did Fuller think, then? In *Synergetics,* he writes that he considers “universe” as the most comprehensive constituent of his ideas.[73] Universe is “the biggest system”, as he calls it in the *Operating Manual,* though he accepts that it is painful to identify it scientifically.[74] However, he writes in the same book that one scientist, Albert Einstein, surpassed the difficulty of dealing with the cosmos holistically, thanks to the energy relations of the universe.[75] As information, Einstein identified the physical universe in the following words: “where the equation E is equal to mc², in which energy is put equal to mass, multiplied by the square of the velocity of light, showed that very small amounts of mass may be converted into a very large amount of energy and vice versa.”[76] Fuller’s interest in the scientists that deal with the energy conditions of the Universe had links with his concern with the systems thinking. Energy accounting is one of the basics of systems research, which helps to understand how the elements of universe are tied in an all embracing network. Yet, he found Einstein’s dictum as insufficient for the reason that it only deals with the physical conditions of the universe, since, as stated by him, there are not only physical, but also metaphysical constituents.[77] According to Fuller, metaphysics, which develop through human intellectual power, has a significant effect in the energy exchange systems of the Universe. This assumption is indeed closer to Claude

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[71] Fuller, 1969, *Operating Manual* p. 59.
[72] Fuller, 1969, *Operating Manual,* p. 59.
[73] Fuller, 1975, p. 81.
[74] Fuller, 1969, *Operating Manual,* p. 60.
[75] Fuller, 1969, *Operating Manual,* p. 62.
[76] Albert Einstein explaining his famous dictum in a press interview in 1948. From the soundtrack of the film, *Atomic Physics* by J. Arthur Rank Organization, Ltd. The film can be viewed in the following website: http://www.aip.org/history/einstein/voice1.htm
[77] Fuller, 1975, pp. 82-84.

Shannon's theory of communication, which indicates that knowledge exchange is subject to energy relations.

In the book *Operating Manual,* Fuller mentions about one of the paradigm shifts in science, which is, the reformulation of the planetary systems as closed, rather than isolated mechanisms in the beginning of the twentieth century.[78] As it has been indicated in the second chapter, in an isolated system, neither energy nor matter is exchanged with the outside world. For instance, the Universe is considered as an isolated system. The entropy production increases incessantly, causing the system's malfunction. However, in a closed system, energy is exchanged with the surroundings. Unlike isolated systems, entropy increase can be controlled by manipulating the energy conditions inside the closed system, so that entropy production tends towards a state of equilibrium, rather than towards malfunction. Therefore, it is possible to conserve and to recycle energy in such a system. For instance, Earth and Sun are considered as closed systems. Indeed, life occurs in such a system because of the entropy control via energy exchange.

According to Fuller, this scientific discovery had also social consequences.[79] It rendered the transformation of culture, from the one that was oriented to consumption, towards conservation. Man can both conserve and enhance the quality of knowledge through exchange of information, like he can conserve and exchange energy in a closed system. In this sense, he writes, "the word "spending" is now scientifically meaningless and therefore obsolete".[80] He believed that this situation was indeed the beginning of the creative man power, whose intellectual capacity, like energy, is subject to conservation and transformation into other forms of thinking. He writes:

> Among the irreversible succession of self-regenerative human events are experiences, intuitions, speculations, experiments, discoveries, and productions. Because experience always alters previous experience, the process is both irreversible and nonidentically

[78] Fuller, 1969, *Operating Manual,* pp. 89-99.
[79] Fuller, 1969, *Operating Manual,* pp. 89-99.
[80] Fuller, 1969, *Operating Manual,* p. 91.

> repetitive. Since experience is finite, it can be stored, studied, directed, and turned with conscious effort to human advantage. This means that evolution pivots on the conscious, selective use of cumulative human experience and not on Darwin's hypothesis of chance adaptation to survival, nor on his assumption of evolution independent of individual will and design. [81]

The unification of human experiences develops a collective mental power being subject to upgrade at every moment in time. Fuller puts in the book *Utopia or Oblivion* that, human cognitive capacity is the real wealth of humanity; contrary to the wealth in monetary terms.[82] He writes that throughout history, the cooperative rationality resulted in the emergence of technological developments, helping in the efficient use of planetary resources. Fuller foresaw a progressive development of human awareness through industrialization. The proper application of industrialization may further Earth's power to regenerate itself. Hence, diversity in the human intellectual capacity -being the real wealth of humanity- resembles biodiversity in nature, as both are the supporters of a self-sustaining and a balanced environment. He writes:

> Sum totally, we find that the physical constituent of wealth-energy cannot decrease and the metaphysical constituent-know-how-can only increase. This is to say that every time we use our wealth it increases. This is to say that, countering entropy, wealth can only increase. Whereas entropy is increasing disorder evoked by the dispersion of energy, wealth locally is increased order…
>
> Wealth is anti-entropy at a most exquisite degree of concentration…Wealth is the product of the progressive mastery of matter by mind, and is specifically accountable in forward man days established metabolic regeneration advantages spelt out in hours of life for specific numbers of individuals released from formerly prescribed entropy-preoccupying tasks for their respectively individual yet inherently co-operative elective investment in further anti-entropic effectiveness.[83]

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[81] Fuller, 1975, p. 223.
[82] R. Buckminster Fuller, 1969, *Utopia or Oblivion*, New York: The Overlook Press, p. 324.
[83] Fuller, 1969, *Operating Manual*, p. 94.

Consequently, Fuller puts in *Synergetics* that human intellect can conform to systems analysis for its being a product of neural scheme, which is a system itself.[84] Then he thoroughly pointed to the peculiarities of human cognitive system. According to him, the first characteristic of the brain system is its elimination of irrelevant details about the investigated problem in order to make an overall understanding. The second characteristic of the brain system, as he puts, is its finding out the shortest way for efficiency in arriving at the correct explanation. He puts that thinking pattern resembles energy patterns of the Universe when it is subject to exchange and transformation; that it follows the most economical path. Moreover, the third characteristic of the thinking process is its tracing a cyclic route in order to take feedback from the brain to verify the response given to the question posed. The response, after confirmed by the main points of recourse on the neural path, returns back to the starting position for re-checking. As he writes in the *Operating Manual*:

> It is characteristic of "all" thinking- of all systems' conceptioning - that all the lines of thought interrelationships must return cyclically upon themselves in a plurality of directions, as do various great circles around spheres. [85]

In this sense, Fuller seems to consider the thinking process as a homeostatic system; taking confirmation on the correctness of answer via the negative feedback. The response meanders through the neural route like energy flowing in the universe, without being subject to any damage or lost. The metaphysical initiative works that way; the totality of thinking processes develops collective cognition, which grows incessantly without any demolition. Hence, the scientific equivalent of the human intellect, according to Fuller, is the equation $(N^2\text{-}N)/2$, where N is the number of breakpoints on the thinking path that the human mind stops to get confirmation from the brain about the correctness of the answer. In other words, it is the number of feedback stops on the brain nervous system. The resulting number defines the

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[84] Fuller, 1975, pp. 234-238.
[85] Fuller, 1969, *Operating Manual*, p. 66.

"conceptuality of number of most economical relationships between events or minimum number of interconnections of all events".[86]

Fuller's path of thinking followed the systems approach; that he gradually set down to the details after a top-down outlook. In view of this, the universe is the topmost element of his philosophical framework. Then he progressively contemplated on the human neural system, as a sub constituent of the universe. Indeed, in *Utopia or Oblivion,* Fuller points to the unfeasibility of pondering on the whole universe without dividing it into certain sub-systems.[87] According to him, generalization is the gathering of case experiences under a pattern of thinking. He believed that after developing generalized structures out of experiences, the human brain drives concepts out of these structures. In *Synergetics,* he writes that he coined the practice of driving concepts as the process of "conceptualization".[88]

Hence, Fuller traced the path of thought from the physics and metaphysics of universe to the human cognitive systems, and then progressively stepped into geometrical patterns in order to end with the formal patterns of architectural construction. In this perspective, Fuller calls the process of finding the geometrical equivalent of the universe's physical and metaphysical sub-systems as the "valving" process.[89] According to him, "valving" makes possible interconnections between energy or information systems through formal diagrams. Fuller conceptualizes his own thinking process by unusual terms and "valving" is one of them.

In the book *Operating Manual*, he briefly explains his thinking path going from human cognition to the geometries of architectural construction.[90] He begins by developing the geometrical equivalent of the cyclic mind patterns. Here, he refers to the Hindu mathematician Reiman, who identifies the energy pattern of the universe in geometric terms. Reiman coins the geometrical correspondent of the energy

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[86] Fuller, 1969, *Operating Manual,* p.68.
[87] Fuller, 1969, *Utopia or Oblivion,* p. 323.
[88] Fuller, 1975, pp. 234.
[89] Robert W. Marks, 1960, *the Dymaxion World of Buckminster Fuller,* New York: Reinhold Publishing Corporation, p. 7.
[90] Fuller, 1969, *Operating Manual,* p. 66.

patterns as “geodesic lines… curvilinear and the most economical lines of interrelationship between two independently moving events”[91], events taking place out of human action. A geodesic line has a geometric shape of an arc of a great circle. Fuller referred to Reiman because he believed that human thinking pattern and the universal energy pattern follows the identical cyclic route. Fuller informs us that Reiman’s geodesic also defines “macro-macro energy cosmos structuring”.[92] It is the largest geometrical element defining the cosmological energy, which indicates how comprehensive Fuller thought on the way leading to his projects and inventions. He revealed his formula of “comprehension” on the basis of this universal geometrical model.

His ideas on the relations of cosmological energy with the brain nervous system might be because of the “information currents” generated by the late 60s systems scientists. As mentioned earlier, systems approach puts that every type of organization in the universe, whether cosmological, biological or cerebral is linked with each other through a comprehensive network. Here, a reminder can be made with a citation from the founder of the systems theory, Ludwig von Bertalanffy, who writes the following in his *General Systems Theory*:

> A consequence of the existence of general system properties is the appearance of structural similarities or isomorphisms in different fields. There are correspondences in the principles that govern the behavior of entities that are, intrinsically, widely different. [93]

As it is understood form the above remark, it is possible to link biological issues with any other phenomenon by finding out their common mathematical arrangement. Indeed information theorists proved in mathematical terms that the negentropy of biological systems and information network of human systems are both linked with the same logarithmic bond. Reiman transformed this mathematical process to a geometrical model, defining the widest energy structuring of the universe. The fact that energy, matter, information and neural transformation following the same

[91] Fuller, 1969, *Operating Manual*, p. 62.
[92] Marks,1960, p.44.
[93] Von Bertalanffy, 1968, p. 32.

intercourse make possible to encounter the same geometrical flow pattern in radio signals traveling from the transmitter to the receiver, or in the fluctuation in the economic means of supply and demand, or in the neural routes in the human brain, vice versa.

3.1.3.1. Fuller's Energetic-Synergetic Geometries

Fuller progressed from the macro to the micro means of structuring the universe via the geodesics. Basically, he utilized the geodesic arc in architectural means of construction by dividing the geodesic structure into 'break points', as in the neural route of the brain. According to Fuller's autobiographer Marks, his conviction was mainly because of constructive reasons; the more 'break points' are in the system, the less vulnerable geodesic structures are to demolition.[94] Obviously, the divisions on the geodesic line should have a geometrical correspondent. In the book *the Dymaxion World of Fuller,* Marks points out that Fuller decided on the geometry of divisions by analyzing the energy and information exchange routes of living systems.[95] He observed how living organisms discovered sub-paths on the main geodesic energy line for the efficient means of exchange. Hence, ecological analysis was the way leading to Fuller's architectural creativity. According to Marks, Fuller's main concern was human exchange patterns:

> He developed, first, a concept of major and minor ecological patterning, that is, regularities in the relations of organisms to their physical environment. For example, birds' seasonal, world-sweeping migrations represented to Fuller a major ecological patterning: birds' nest-building and "local regenerative to-and-fro-ing." He regarded as the related minor ecological patterning. He drew parallels with the human situation, developing a concept of major and minor ecological controls in the economic life of homo sapiens. Here the world's industrial network emerged as the major control. The minor, or local, ecological control was shelter. With his usual comprehensiveness, however, Fuller conceived of shelter as virtually

[94] Marks, 1960, p. 44.
[95] Marks, p. 39.

> everything which gave man a local technical advantage in his struggle against the elements. It included not only a house, but the utilities which tended to make a house autonomous and the transportation which shuttled a man between his place of work and his place of physiological renovation.[96]

Systems thinking provided Fuller a wide spectrum of interconnections between ecological and human organizations, such that he could link animal flow with capital circulation, or ecological accommodation with the architecture of shelter. Indeed, the biologist Ernst Haeckel, while he put forward the term “ecology”, announced the correspondence between the natural and the man-made agenda at the same time, which was a century earlier than systems approach tied them through energy and information exchange.[97] Interpreted as ‘the knowledge of the household economy’ from its Greek origins, the term indicates that survival requires information on the most efficient means of household management. The economy of dwelling is the key knowledge for the continued existence on earth. Ecology informs man the efficient means of habitation on our planet.

Fuller contemplated on the physical and metaphysical system of the universe as represented by geodesic lines, which he progressively applied to the energy geometries of our ecological environment. He investigated the minor and major ecological patterning of biotic matter into three dimensional configurations, which formed the geometrical basis of his architectural shelters. Marks briefly explained in his book *the Dymaxion World* that Fuller presented energy and matter exchange of living systems by using triangular geometries, which he coined as “Energetic-Synergetic Geometry”, and the common element of which is tetrahedron, a four-faced pyramid.[98] The reason for his choosing triangular subdivisions for his synergetic geometry is because that they “represent the shortest, most economical

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[96] Marks, p.19.
[97] The architectural theoretician Mark Wigley briefly analyzed Fuller’s frame of thinking with regard to Haeckel’s understanding of ecology under the article entitled “Recycling Recycling”, in Amerigo Marras, (ed.), 1999, *Eco-Tec*:*Architecture of the In-Between*, (New York: Princeton Architectural Press), pp. 39-49.
[98] Fuller, 1969, *Operating Manual,* p. 13.

energy networks".[99] Fuller held that energy transformation occurs on a triangular path because of its being the short cut for destination, and that condition is applicable for all cosmological, biological and informational systems. In this sense, while triangle is the basic geometrical unit representing the most efficient organization for energy exchange, tetrahedron is the basic structural system which is formed by the cluster of triangles (Fig. 3.6). He writes in *Synergetics*:

> If the system's openings are all triangulated, it is structured with minimum effort. There are only three possible omnisymmetrical, omnitriangulated, least effort structural systems in nature. They are the tetrahedron, octahedron and icosahedron."[100]

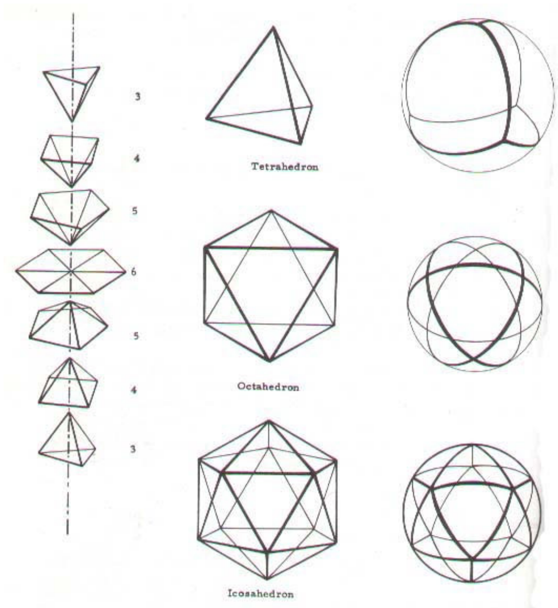

Fig. 3.6. Three basic geometries of Fuller's triangular family.
Source: Buckminster Fuller, 1975, *Synergetics: Explorations in the Geometry of Thinking*. New York: Macmillan Publishing Co., Inc., p. 322.

[99] Fuller, 1969, *Operating Manual,* p. 43.
[100] Fuller, 1975, p. 321.

Furthermore, in the same book, he refers to the biologist Ernst Haeckel, who developed a taxonomy of symmetrical shaped living organisms, in order to display how the tetrahedral-shaped structures are commonly found in nature[101] (Fig. 3.7).

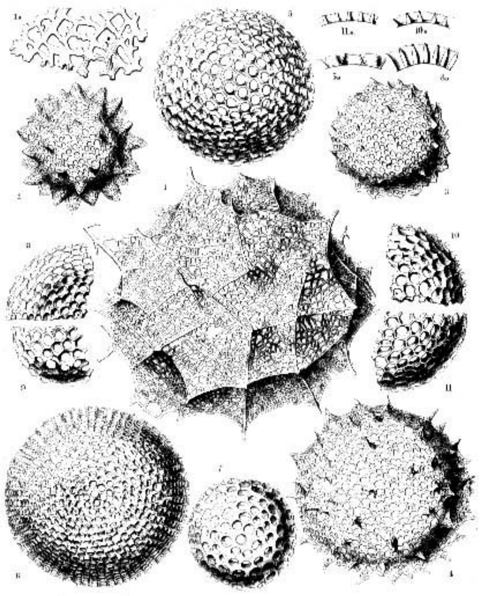

Fig. 3.7. The synergetic system of nature as depicted by Ernst Haeckel.
Source: Buckminster Fuller, 1975, *Synergetics: Explorations in the Geometry of Thinking.* New York: Macmillan Publishing Co., Inc., p. 25.

Accordingly, the most comprehensive structure in this synergetic system is, as he calls it, the "vector equilibrium", which is the combination of the octahedron with tetrahedral geometries. In *Synergetics,* he writes about how he deduced the "vector equilibrium":

> The geometric form most compactly developed from the closest packing of spheres around one nuclear sphere is not that of a composite sphere, but is always a polyhedron of 14 faces with 12 vertexes extended in tangential radius from the original 12 spheres surrounding the

[101] Fuller, 1975, p. 25.

> nucleus sphere. The vector equilibrium consists of six one-half octahedra and eight tetrahedra.[102]

From the above remark, it can be understood that Fuller deduced the geometry of the synergetic system by drawing the triangular contours of a spherical shape, which he coined as “closest packing of spheres”, which is the convergence of spheres around a central sphere. Here, the sphere represents the circular channel of energy feedbacks on the geodesic line. Marks points out that Fuller considered the sphere shape as “an idealized model of energy in which all forces are in equilibrium, and whose vectors, consequently, are identical in length and in angular relationships.”[103] His unification of the spherical geometry with triangular one depends on the nature of energy flows, which create triangular passageways while tracking the circular canal simultaneously. As mentioned earlier, energy transfer is possible via triangle-shaped sub-paths on the geodesic system. In summary, the circular paths are bisected by triangular sub-paths and the result is the fundamental synergetic system in nature, which is geometrically represented in the “vector equilibrium” structure. (Fig. 3.8.)

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[102] Fuller, 1975, pp.152-153.
[103] Fuller, 1969, *Operating Manual,* p. 40.

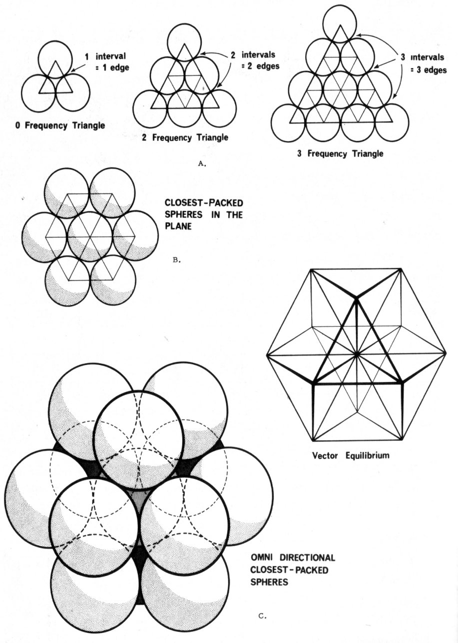

Fig.3.8. Diagram showing Fuller's deduction of the "vector equilibrium" out of the closest packing of spheres.
Source: Buckminster Fuller, 1975, *Synergetics: Explorations in the Geometry of Thinking,* New York: Macmilan Publishing Co., Inc., p. 118.

As a result, Fuller's breaking points on the geodesic line were defined in terms of energetic-synergetic geometries, which are all based on the principle of "vector equilibrium". In *Synergetics,* Fuller defines the "vector equilibrium" as a stable structural system representing the energy trajectories on the universe, in which the forces are identical at every point.[104] Furthermore, he explains why he defines his equilibrium system in terms of vectors, rather than lines. He informs that a line cannot represent the energy that travel on the universe in terms of the "waves consisting of frequencies of directional inflections in respect to duration of experience".[105] He points out that vectors present direction and velocity of forces, which operates in a flow of energy, as it is transferred in an environment. As a result, the vector equilibrium structure was developed out of the assumption that both

[104] Fuller, 1975, p. 258.
[105] Fuller, 1975, p. 258.

energy in macro or quanta scale "interact in the same way, moving toward the most economic equilibrium patternings".[106]

From 1927 till his death in 1983, Fuller was continuously involved with architectural production, which the outcome was branded under such terms as "tensegrity", "octa spinner", "catenary", "aspension" etc., save for "geodesic" or "dymaxion". Generally, all of them belonged to the same energetic-synergetic set-up, though they appeared in the diverse periods of his life. The energy relationships of ecological environment gave Fuller clues about the sub-structuring of cosmological forces, and thus about the most efficient means of architectural construction.

3.1.3.2. On Fuller's Inventions

Fuller inferred manifold geometrical structures out of the cluster of triangles. His earliest architectural invention was his "Dymaxion" dwelling units, a 14-faced triangular volume being open to extrusion, based on a modular layout. [107] He firstly proposed "Dymaxion" in the 30s as a prefabricated housing unit made up of aluminum alloys and steel, which can be demountable and transportable by a large car or an airplane. It has a central load bearing mast that carries the entire volume. The volume is mechanically controlled via the apparatuses located on the ceiling structure. A mechanical implantation is utilized for providing an indoor climate that is different from the outside environment. The walls are partitioned via such utilities as grill, library and bathroom (Fig. 3.9).

[106] Fuller, 1975, p. 28.
[107] The name "Dymaxion" was coined in 1927 by those who were responsible for the trade of Fuller's inventions. See Robert W. Marks, *The Dymaxion World.*

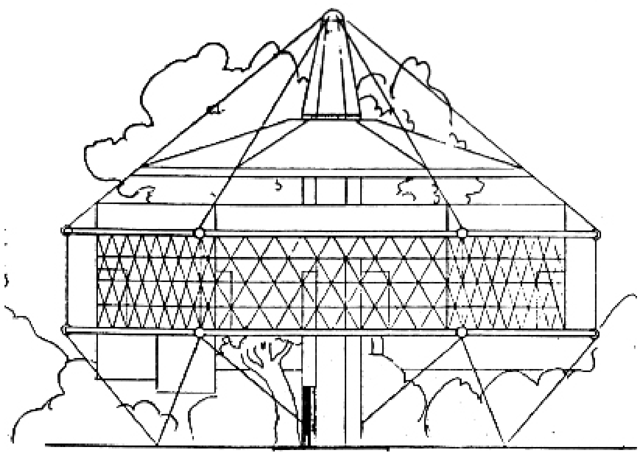

Fig. 3.9. *R. Buckminster Fuller,* The Dymaxion Dwelling Unit, *1927. Elevation.* Source: Robert W Marks, 1960, *The Dymaxion World of Buckminster Fuller.* New York: Reinhold Publishing Corporation, p. 82.

Fuller re-considered the modular system two decades later for a rapid construction in especially earthquake-devastated areas, under the name "Dymaxion Dwelling Machine".[108] In *Nine Chains to the Moon*, he points out that architects should apprehend Le Corbusier's dictum "the house is a machine for living in" in order to cope with the needs of the contemporary industrialized world system.[109] Hence, his dwelling units, designed for cost-effectiveness in the household life, might be examples for humanity's efforts on the road leading to the economy of nature. Since they were the direct outcome of information transfer from nature, they offer an efficient model of occupancy akin to the one of natural environment. The supporting sub-structures of units came out through a proper design of macro and micro geometries in the ecological patterns. The Dymaxion architectural system was modularly divided into primary and secondary components, such that the unit became ready for industrial manufacturing (Fig.3.10).

[108] The information of the Dymaxion Dwelling Machine can be obtained from Robert Marks*, The Dymaxion World,* pp. 120-133.
[109] R. Buckmisnter Fuller, 1938, *Nine Chains to the Moon,* New York: J. B. Lippincott Company., p. 360.

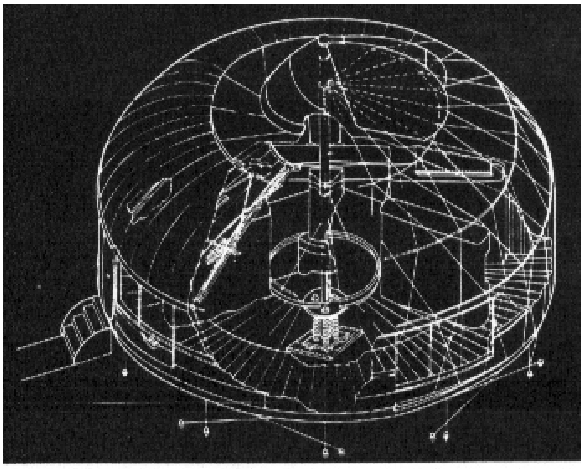

Fig. 3.10. *R. Buckminster Fuller,* The Dymaxion Dwelling Machine, *1944. Axonometry.*
Source: Robert W Marks, 1960, *The Dymaxion World of Buckminster Fuller.* New York: Reinhold Publishing Corporation, p. 123.

In *Utopia or Oblivion*, Fuller writes that industrialization, being the achievement of human intellect, is the driving force behind architecture in the quest for economic means of dwelling on the planet earth.[110] According to him, manufactured products support the earthly regenerative system by orienting humanity to the efficient means of inhabitation. Hence, in *Nine Chains to the Moon,* Fuller puts that architecture should be a part of this regenerative world system by means of the "energy slaves", which are the mechanical products enhancing the quality of metaphysical initiative.[111] According to him, architects should find ways to industrialize housing systems; however, they are stuck within the age-old discourse on aesthetics. In *Inventions,* he writes that aesthetics is the least important criterion of his creations: "Beauty to me must be a product result and not a purpose".[112]

[110] Fuller, 1969, *Utopia or Oblivion,* p. 323.
[111] Fuller, 1938, p. 40.
[112] Fuller, 1983, p. 129.

In this sense, technological facilities, which are provided alongside household organization, gain significance for Fuller on the struggle for planetary survival. He writes in the book *Utopia or Oblivion* that if one aspect of industrialized maintenance is the building construction system, the other one is the technological accessories of modern life assisting man in their everyday lives.[113] Hence, industrial products support man on the way to discovery of ecological ways of residing on earth. Examples for the industrial products are the communication and transportation apparatuses, such as telephone, car, plane, etc. He writes in the *Operating Manual* that the manufactured products are the tools that reinforce human capacity in the adaptation to the natural environment:

> Thus again we see that, through gradually increasing use of his intuition and intellect, man has discovered many of the generalized principles that are operative in the universe and has employed them objectively but separately in extending his internal metabolic regeneration by his invented and detached tool extensions and their remote operation affected by harnessing inanimate energy…
>
> Man is unique among all the living phenomena as the most adaptable environment penetrating, exploring, and operating organism being initially equipped to invent intellectually and self-disciplined, dexterously, to make the tools with which thus to extend himself… Man externalizes, separates out, and increases each of his specialized function capabilities by inventing tools as soon as he discovers the need trough oft-repeated experiences with unfriendly environmental challenges… Man cannot compete physically as a muscle and brained automaton –as a machine-against the automated power tools which he can invent while metaphysically mastering the energy income from universe with which evermore powerfully to actuate these evermore precise mass-production tools. What man has done is to decentralize his functions into a world-around-energy-networked complex of tools which altogether constitute what we refer to as world industrialization.[114]

Indeed, Fuller aimed at the contribution of the repair and maintenance of our planet through architectural practice at not only in household level, but also at larger scale. Our ecological future was supposed to develop around the technologically-implanted vertical forms as well. He writes in *Utopia or Oblivion* that the systems

[113] Fuller, 1969, *Utopia or Oblivion,* p. 323.
[114] Fuller, 1969, *Operating Manual,* pp. 113-114.

methodology, which he put forward in his Dymaxion Dwelling Machines, should be applied to larger-scale architectural structures for a self-regulating environment.[115] For that, he envisioned multifunctional architectural complexes that were ten times the height of the Empire State building. He believed that a tetrahedronal structure is more rigid than any other geometry for a vertical development. It was assumed to be supported through a tripod-like foundation to enhance rigidity. Each tetrahedron was assumed to house a million dwellers, or 250 families. Each family would occupy two thousand square meters flat. The tetrahedrons, when they come together, will comprise a spaceship city endowed with proper waste and water management systems. Like a living organism, they would efficiently cycle energy via an appropriate technology. They combine living, working and leisure in a single volume. As the context in which they were erected required a great deal of square meter area, Fuller assumed that aquatic environment would be the best for their construction. Hence, the tetrahedronal city would be the part of world ocean ecosystems as the result of its steady-state configuration (Fig.3.11).

[115] Fuller, 1969, *Utopia or Oblivion,* pp. 343-363.

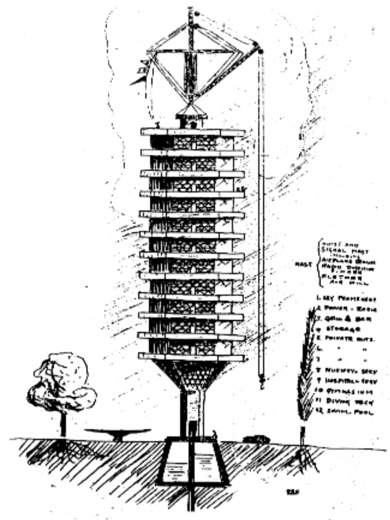

Fig. 3.11. *R. Buckminster Fuller,* The tetrahedronal skyscrapers, *1927. Elevation.*
Source: Robert W Marks, 1960, *The Dymaxion World of Buckminster Fuller.* New York: Reinhold Publishing Corporation, p. 74.

Consequently, the "octet truss", which is a truss system made out of the combination of octahedron and tetrahedron geometries, was another Fuller discovery. It is a semi-open cover structure which does not envelop the entire content (Fig. 3.12).

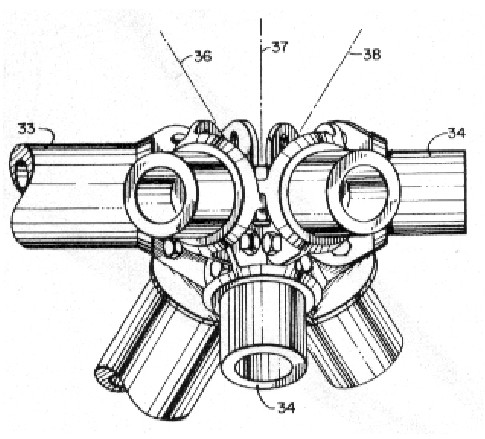

Fig. 3.12. *R. Buckminster Fuller,* Octet Truss, *1961. Perspective of the structural system.*
Source: Buckminster Fuller, 1983, *Inventions: The Patented Works of Richard Buckminster Fuller.* New York: St. Martin's Press, pg. 176.

Fuller continued his inventions in 1962, and deduced a cluster of triangles having a spherical shape in particular, which balances compression weights with its genuine tension system.[116] Named as "tensegrity", which is a system of tensional integrity, it domes over architectures in big scale. The entire structure reduces the compression that occurs when the span of a dome increases in diameter, so that the rigidity is enhanced. Like the Dymaxion dwelling machine, its modular assembly enables rapid construction (Fig. 3.13). In this view, Fuller writes the following:

> Tensegrity has special application to structures of vast proportions such as free-span domes capable of roofing a stadium or housing an entire village or city, and to mammoth air-flotable spheres as well as collapsible light weight structures adapted to be transported by rocket.[117]

Fig. 3.13. *R. Buckminster Fuller,* Tensegrity*, 1962.*
Photograph by the author.

However, among Fuller's architectural inventions, the geodesic dome, which took shape as early as the 30s, has become the most famous.[118] As it was mentioned in the above paragraphs, the structural integrity of the dome is enhanced when it is incorporated within the vector equilibrium systems, which are designed with the

[116] Fuller, 1983, pp. 179-194.
[117] Fuller, 1983, p. 180.
[118] Fuller, 1983, pp. 127-145.

breaking points, as in the geodesics of the universe. The geodesic structure can stretch and contract flexibly to conform to irregular surfaces and volumes (Fig.3.14).

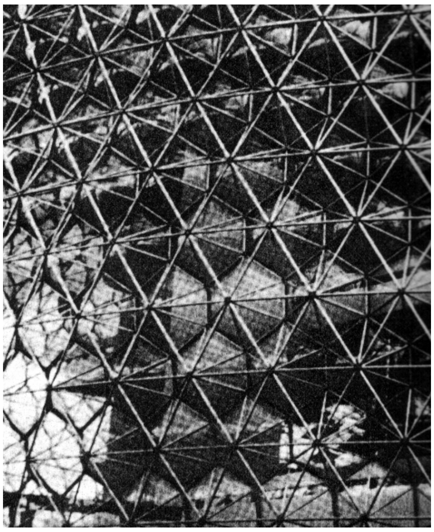

Fig. 3.14. *R. Buckminster Fuller,* Geodesic Dome, *1954. Photograph of the structural system.*
Source: Buckminster Fuller, 1983, *Inventions: The Patented Works of Richard Buckminster Fuller.* New York: St. Martin's Press, pg. 138.

Fuller even proposed a domed-over city, to cover the entire Manhattan region of New York in the late 60s.[119] Indeed, his domed over Manhattan did not comprise solely a structure. It was planned as a closed system, a city over the city that had its own climatic conditions inside and that sustained its own homeostasis owing to its cycles of energy. Fuller envisioned his equilibrium structures leading towards not only vertical direction, but also horizontal one as well. He assumed that his geodesic domes would be the most appropriate structure for that purpose. A geodesic structure can cover an area two-mile-in-diameter, which would float as a gigantic spaceship on world oceans.

[119] Fuller, 1969, *Utopia or Oblivion,* p. 353.

Fig. 3.15. *R. Buckminster Fuller,* The Domed-over Manhattan.

Source: Ed Melet, 1999, *Sustainable Architecture,* Rotterdam: NAI Publishers, p. 164.

A variety of geodesic structures were produced around the world especially within the two decades following its invention. For instance, Paolo Soleri, the Italian architect famous for his reinforced concrete settlements on the Arizona desert, erected an underground house for his mother-in-law in 1949.[120] He domed it with the geodesic structure made out of aluminum panels of aircraft garbage. Here, he elevated the central foci of the dome to gain space in order to locate the mechanics of environmental control. As he mentioned in a conversation, the influence of Buckminster Fuller was clearly evident in his design[121] (Fig. 3.16).

[120] Antonietta Adriana Lima, 2003, *Soleri: Architecture as Human Ecology,* New York: The Monacelli Press, p. 115.
[121] Soleri, interview by Lima, 2003, p. 115.

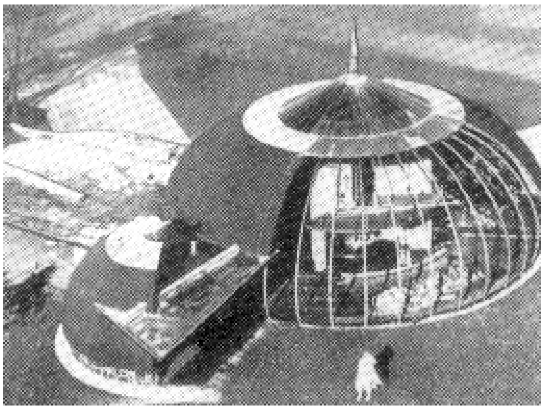

Fig. 3.16. *Paolo Soleri,* Dome House, *1949.*
Source: Antonietta Adriana Lima, 2003, *Soleri: Architecture as Human Ecology,* New York: The Monacelli Press, p. 119.

Another example is the Drop City in Colorado, which was the group of houses for the hippie commune in the 60s, and which will be explained in the subsequent paragraphs. It was developed out of geodesic domes that were produced with the industrial garbage products. Today, geodesic structures are still being used for sheltering diverse architectural facilities, which will be explained in the subsequent chapter.

Colin Porteous, in his book entitled *The New Eco-Architecture*, puts that Fuller's architectural practice under the support of systems thinking ascended the interest of architects towards environmental issues.[122] According to him, it renders the emergence of two contradictory impulses regarding the survival on our planet. On one hand, his prefabricated systems enhanced the contribution of architecture to the industrially-driven world system and thus fuelled the optimistic ideals on the future of humanity that is used to solve worldly problems through science and technology. On the other hand, his design of emergency shelters generated a more pessimistic wave among those who believed that human's destructive impulse will lead to its extinction, such that the contemporary world would be forced to provide its own

[122] Colin Porteous, 2002, *The New Eco-Architecture: Alternatives from the Modern Movement,* London and New York: Spon Press, p. 36.

basic needs with the most primitive means. Despite that, he believes that Fuller's inventions are not environmentally appropriate regarding the current criteria of sustainability, despite his influences on the 60s intellectual environment as well as the contemporary green architectural thought.[123] According to him, they bypass environmental well-being while providing conditions for the human well-being. As mentioned earlier, Fuller's dwelling machines provide an indoor climate isolated from the one of outside. They were closed systems for climatic comfort of human being that operate under the cycles of universal energy. The mechanical hardware provided a feedback system that counterbalanced the waste energy, which was emitted to the outside environment, with the input energy. Porteous puts that the energy processing inside the structure, while is vital in acquiring climatic comfort, is at the same time harmful to the environment.

Despite that his inventions are not environmentally-appropriate, still Fuller was uncomfortable with the human contribution to environmental ills. He found the public education on environmental matters as crucial. Like his contemporaneous systems thinkers, Fuller saw our world as a spaceship which needs proper maintenance to enable energy circulation. Also like his contemporaneous, he found the earth spaceship as a homeostatic machine, like a car that occasionally requires repair:

> One of the interesting things to me about our spaceship is that it is a mechanical vehicle, just as in an automobile. If you own an automobile, you realize that you must put oil and gas into it, and you must put water in the radiator and take care of the car as a whole. You begin to develop quite a little thermodynamic sense. You know that you're either going to have to keep the machine in good order or it's going to be in trouble and fail to function. We have not been seeing our Spaceship Earth as an integrally-designed machine which to be persistently successful must be comprehended and serviced in total.
>
> Now there is one outstandingly important fact regarding Spaceship Earth, and that is that no instruction book came with it […] So we were forced […] to use our intellect, which is our supreme faculty, to devise scientific experimental procedures and to interpret effectively the significance of experimental findings. Thus, because the instruction manual was missing, we

[123] Porteous, p. 36.

> are learning how we safely can anticipate the consequences of an increasing number of alternative ways of extending our satisfactory survival and growth-both physical and metaphysical.[124]

The lack of an instruction book may enhance earth's poor health. May that be the precursor for the end of humanity? Fuller endowed a more depressing picture regarding human endurance on earth towards the end of his life. The preface of the book *Inventions*, which he writes in his last years, displays his anxiety about human extinction.[125] Furthermore, it is observed that his holistic approach attained a Gaian perspective. He writes on his belief in the superorganismic capacity of Earth that helps to sustain its homeostatic power everlastingly, both with the help of God's power and support and for the sake of human annihilation. The superorganism hypothesis strengthens the faith in the internal motivation of the whole universe, and thus, brought forward theological counterparts to the discourse. Throughout the article, Fuller displayed his reliance on "the eternal cosmic intelligence we call God"[126], alongside his belief in the human intelligence for planetary survival. Indeed, despite the dualities of technocratic and humanistic viewpoints, being brought forward to challenge the dissolution of every detail into one singular pot, systems thinking eventually arrive at the oneness of phenomena, thanks to its holistic outlook.

As it will be seen in Chapter 4, contemporary green architects who accentuate technological paradigms take fully advantage of Fuller's systems thinking. As the above paragraphs display, Fuller supported the equilibrium vision, being the dominant systems model of the 60s. His energetic-synergetic geometries are part of his envisioning of the universe in which its energy forces tends towards equilibrium. They took shape in the hands of a designer who had an image of planet earth that sustains its equilibrium with the aid of human maintenance and repair. However, it is understood that Fuller's faith on humanity was altered towards a bias on superorganismic earth that sustains its equilibrium despite human help. His large-scale urban visions coupled with his geodesic doming over the world might have

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[124] Fuller, 1969, *Operating Manual for Spaceship Earth,* pp. 52-53.
[125] Fuller, 1983, p. vii-xiii.
[126] Fuller, 1983, p. xxxii.

nourished his credence on earth's inner spirit. Hence, Fuller seems to abandon dualities in favor of oneness of systems in his later periods.

3.1.4. The Adherents of Fuller's Vertical Vision: a Concise Glance to the Developers of the 60s Cybernetic Urban Models

Fuller shifted his vision of a household-level economy to a larger-scaled-level in his later practices. That condition provided the basis for the contemporary architectural efforts regarding the enhancement of environmental efficiency within massive structures. Accordingly, Fuller's ten proposals for the world improvement, which he published in his book *Earth Inc.,* is the precursor of his late discourse on the superorganismic earth.[127] Here, he envisions a gigantic world organization that unites every nation's monetary, educational, democratic, arrangements into one territorial bond. Indeed, he writes in *Earth Inc.,* that his assumptions are in a way closer to Doxiadis' "Ecumenapolis" vision. "Ecumenapolis" is a proposal for an urban structure that was generated according to the systems principles by the urban planner Constantin Doxiadis in 1969. It is assumed as a one world city made up of settlement cells, units of habitation up to 50,000 people. Here, Doxiadis envisioned a global future in which all the human ecosystems are brought together into a single superorganism.

In fact, we owe the resilience of Fuller's vision for a large-scaled urban self-sufficiency today not only to Fuller himself, but also to those who share his systems model in the 60s. From the English Archigram group to the Japanese Metabolists, the floating spaceships embellished the prophecies for a utopian urban development. The following paragraphs will give place to those who followed Fuller's cybernetic vertical development models in the 60s.

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[127] R. Buckminster Fuller, 1973, *Earth Inc.,* New York: Anchor Books, pp. 173-180.

3.1.4.1. Archigram's Computer-Controlled Plug-Ins

Fuller's Tetrahedronal Cities fueled those who envisioned our urban future in a larger-scaled cybernetic environment and such was the English group Archigram, which is active in the 60s and early 70s. In the retrospective book entitled *A Guide to Archigram*, which was published following the Archigram exhibition in Germany in 1990, there is given information on the group's enthusiasm regarding the subject-matter.[128] As put forward in the book, the group considers their architecture as an instrument for the information exchange in an urban fabric.[129] According to them, urban communication network resembles the brain nervous system, in which the information is controlled via feedback response. Warren Chalk, one of the group members, informs the readers on the operation of a feedback scheme: "In a cybernetic system, there is some method of monitoring the output of the system, comparing it with a desired result and using the difference to actuate some control mechanism to adjust to the required form".[130]

David Greene, another group member, put that architectural productions should conform to this canon of exchange.[131] He believes that the built form should be designed to enable renewal through the exchange of material hardware. It should be revised in 15 year periods through the replacement of the used hardware with the new equipment and that should be as easy as the repair of a car. Furthermore, he points out that computer tracking is needed to maintain the proper replacement of hardware.[132] Just like computer hardware is operated via program softwares, the building hardware should also be subject to control via software systems. In this sense, as he puts, exchange increases the possibility of human survival in an urban

[128] *A Guide to Archigram: 1961-1974,* 1994, London: Academy Editions.
[129] *A Guide to Archigram,* p. 40.
[130] *A Guide to Archigram,* p. 286.
[131] *A Guide to Archigram,* p. 224.
[132] *A Guide to Archigram,* p. 222.

structure. [133] Consequently, he puts that not only built forms, but also every element making part of the totality of the urban system should be subject to this computerized control. Dennis Crompton, another member of the group, points out that they consider the city as an organism in which feedback control is maintained through computer software.[134] Hence, their first proposal, the *Plug-in-City*, was developed according to this vision in 1964:

> In systems planning we are reaching to the point where the 'software'- the unseen relationship- is sufficient to determine the control and positioning of elements in which we live. The environment can now be determined by a systems analysis of our requirements, and the 'seen' world could become servant to the 'unseen' motivation… The Plug-in-City needed the Computer City as its shadow, otherwise it could not function.[135]

The Plug-in-City was a group of skyscrapers that are comprised of dwelling units attached to a vertical reinforced concrete support located at the center. The units were supposed to be replaceable by another one that is designed according of up-to-date technology. "The statement was a capsule dwelling with the ergonomy and sophistication of a space capsule",[136] writes Peter Cook, the architect-member of the group, and continues: "These units are planned for obsolescence"[137] … there would be a continual exchange taking place, with constantly changing and evolving parts".[138] The units are replaced with the aid of cranes that move along a triangular structured railway system that reaches atop of the structure. Hence, the plug-in forms conform to the inevitable phenomenon of degradation in the urban decay through their ethereality (Fig. 3.17).

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[133] *A Guide to Archigram,* p. 224.
[134] *A Guide to Archigram,* p. 242.
[135] *A Guide to Archigram,* p. 222.
[136] *A Guide to Archigram,* pp. 154.
[137] *A Guide to Archigram,* pp. 114.
[138] *A Guide to Archigram,* pp. 154.

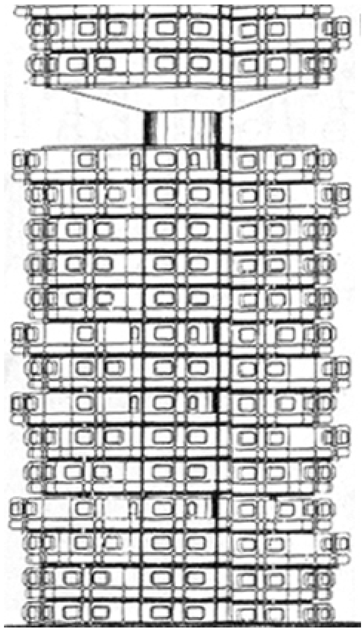

Fig. 3.17. *Archigram*, The Capsule, *1964. Elevation.*
Source: *A Guide to Archigram: 1961-1974,* 1994, London: Academy Editions, p. 154.

Although Archigram members were not concerned about the environmentally-sound systems at that time, they were critical to the human destruction of natural environment, the evidence of which was clearly displayed through urban ills. Warren Chalk warns about the extinction of humanity as the result of the ascension of the environmental exploitation.[139] He suggests being involved with the planetary repair and maintenance through technological know-how, rather than by remembering our past environmentally-sound roots. He disavows arcadian mentality and points out that the self-built activities and shanty towns that were built with regard to the needs of the hippie community cannot develop a healthy urban environment. He writes:

> Ecology is a social problem… Pollution is insidiously growing. Either the environment goes or we go. And you all know what will happen if the environment goes. We have produced a society with the production for the sake of production. The city has become a market place, every human being a commodity. Nature is a resource. Human beings are a resource. Well. Our very survival depends on an ecological utopia, otherwise we will be destroyed.

[139] *A Guide to Archigram,* p. 359.

> This technological backlash we are experiencing must be fought with a more sophisticated technology, a more sophisticated science. Present beautiful chemistry has turned out as not so beautiful biology. But if we are to prevent eco-catastrophe it can only be done by more sophisticated environmental systems, not by drooping out. Nor the hippy type philosophy… Let's face it, total dispersal won't work economically any more than total centralization. Apart from being a head-in-the-sand attitude we need to fight technology, to produce David Greene's cybernetic forest. Too simplistic translations of technology average out people's lives. What we look for is a technological play, so that individuals can create an ever greater environmental stimulation.[140]

Archigram's plugged-in visionary solutions to urban ills were simultaneously eveloped by an assembly of Japanese architects, namely "Metabolists" in the 70s. The Nagakin Capsule in particular, which was designed and realized by the member Kisho Kurokawa, is a high-rise structure that is comprised of prefabricated capsule-like dwellings that are carried through the tube-sectioned central core[141] (Fig.3.18).

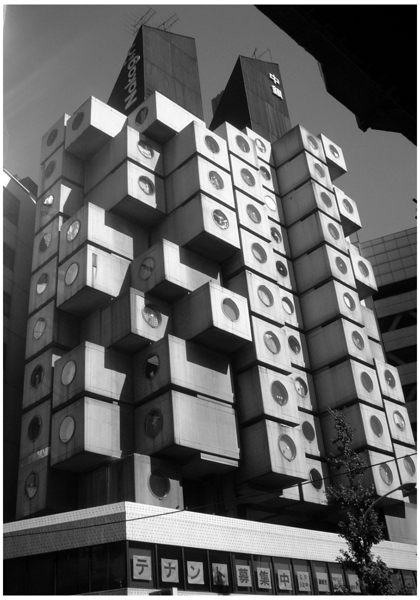

Fig. 3.18. *Kisho Kurokawa,* Nagakin Capsule, *1972.*
Photograph by the author.

[140] *A Guide to Archigram,* pp. 359.
[141] For the details of Metabolist projects, see Kisho Kurokawa, *From Metabolism to Symbiosis,* 1992, London: Academy Editions.

The group came together in the end of 50s and developed a couple of imaginative urban projects that were supposed to produce alternative solutions to the ongoing metropolitan development of Tokyo, via metabolic urban structures.[142] They considered the urban structure as an open system that conditions its self-sufficiency through an organization that is akin to the metabolic functioning of a living organism. While ecological concerns had not yet gone through their intellectual milieu in those years, they were not so far to those either. Biological entities were analogical tools in their visual expression. Their large-scaled architectural proposals had come out mainly by replicating human DNA. The helix-wrought extensions were architecturally expressed as vertical shafts providing suspensions for the nucleic-acid-shaped living pods. The units were demountable, addable and replaceable, representing growth and change in biological systems. Their Metabolist architectural philosophy took support from Fuller's systems approach.

3.1.4.2. Japanese Search for Symbiotic Urbanism

The journey of Metabolists to human DNA begins in 1961 with their proposed Helix City Plan for Tokyo. Here, the city was considered to be out of DNA-shaped skyscrapers floating on the ocean. The dwelling units are mounted on a central core and are cantilevered within the structural framework developed out of the DNA (Fig. 3.19).

[142] The information about the Metabolists were complied from by Kisho Kurokawa' book entitled *From Metabolism to Symbiosis*. See Kisho Kurokawa, 1992, *From Metabolism to Symbiosis,* London: Academy Editions.

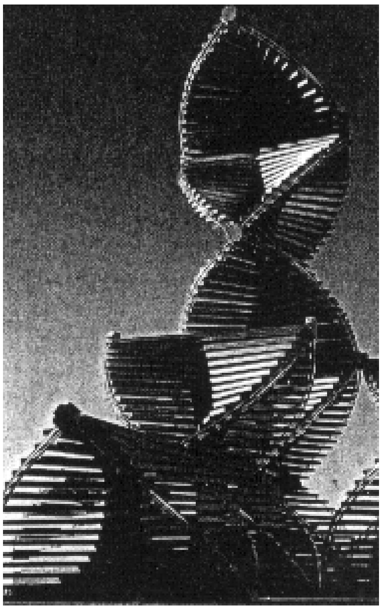

Fig. 3.19. Helix City Plan for Tokyo, *1961.*
Source: Kurokawa, Kisho. 1992. *From Metabolism to Symbiosis.* London: Academy Editions, p. 35.

In 1968, a pavilion was planned for Toshiba Company, with tetrahedron shaped units made of welded steel. The exhibited structure, as the member Kisho Kurokawa informs us, "took the double helix of DNA as its pretext."[143] It had a flexible configuration arranged to meet other functional requirements than exhibition purposes. The units were prepared in five diverse types to be selected by a computer in accordance with different functions and to be combined freely under a space frame (Fig.3.20).

[143] Kurokawa, 1992, p. 14.

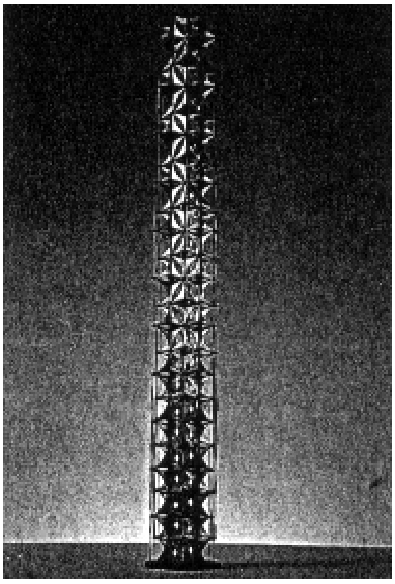

Fig. 3.20. Expo Toshiba IHI Pavilion, Osaka, Japan, *1968.*
Source: Kurokawa, Kisho. 1992. *From Metabolism to Symbiosis.* London: Academy Editions, p. 47.

The group developed a different DNA configuration in another project named "Metabonate Factory" at the end of 60s, a building envisioned as floating on the ocean with residences arranged helicoidally. The factory was the architectural equivalent of a marine city that was designed by Kiyonari Kikutake, a member of the group, to provide its own energy.[144] It was composed of cell dwellings attached to large cylinders floating on the sea (Fig.3.21).

[144] Kenneth Frampton, 1992, *Modern Architecture: A Critical History,* 3rd ed., London: Thames and Hudson, p. 282.

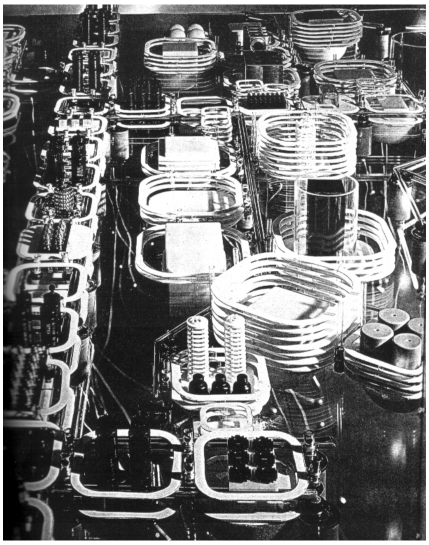

Fig. 3.21. Floating Factory 'Metabonate', *1969.*
Source: Kurokawa, Kisho. 1992. *From Metabolism to Symbiosis.* London: Academy Editions, p. 55.

The member Kurokawa's interest in ecological subject-matter continued even after the decline of the Metabolist project in the mid 70s. Two decades later, he ended up with a book entitled "The Philosophy of Symbiosis", in which he compiled his ideas on architecture.[145] In the book, he writes on the philosophical background of the Metabolist projects that were nurtured by the systems approach. Briefly, in the book, he writes that the aspiration to life forms was a fundamental principle in their architecture. He writes: "The architecture of metabolism is the architecture of the information age. Invisible information technology, the life sciences and biotechnology produce architectural expression."[146] According to Kurokawa, their appeal to life sciences was due to the awareness that "survival of humanity depends on the symbiosis of the many life forms on our planet".[147] He informs that the biological subject-matter had a substantial place in their architectural thinking. He emphasizes that the word "symbiosis" is the term that best fits their philosophical

[145] Kurokawa,1992.
[146] Kurokawa, p. 10.
[147] Kurokawa, p. 7.

approach to architecture.[148] First of all, as he informs us, “symbiosis” summarizes the condition of the current worldly social structure. According to him, “symbiosis” indicates cooperation in diverse aspects; of regional cultures with universal order, nature with architecture and tradition with technology, which according to him was conceived as binary opposites in Western thought. He assumes that a shift from the “Machine Age” to the “Age of Life” is experienced at present, and Metabolists captured that transformation by representing the condition. The Machine Age represents industrial rationality, human subjugation of nature, Western imposition of its value system to other cultures and a quest for universalism and domination based on economic and military might. The Age of Life corresponds to the bio-engineered modes of production, celebration of cultural differences, human awareness on ecological concerns, and an interest in Eastern belief systems in the Western world in parallel with the emergence of systems sciences.

Kurokawa puts that the slogan "A Tea Room in the Space Shuttle", properly fits to the symbiotic condition of humanity that reconciles the technologically-driven present with their past:

> "A Tea Room in the Space Shuttle" is the slogan I have invented to express the symbiosis of humanity and technology. The space shuttle flying through the heavens at a tremendous clip does not by itself represent mature technology. Only when a space shuttle that includes the human space represented by the tea room is launched will it be able to bring a new enjoyment and pleasure to human beings.[149]

Indeed, as Kurokawa’s writings suggest, Metabolist projects were developed in the period in which there was a transition in the society, from the mechanic to the symbiotic patterns of living. Accordingly, as he informs us, the philosophical background of this symbiotic approach to the worldly affairs was prepared by systems scientists of the post-war era.[150] First of all, he puts that Ludwig von

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[148] Kurokawa, pp. 7-30.
[149] Kisho Kurokawa, 2004, *From Metabolism to Symbiosis,* http: //www. kisho.co.jp (accessed January 2006).
[150] Kurokawa, 1992, p. 22.

Bertalanffy's writings are a source of information that gives concise information on the subject. Furthermore, he puts that the writings of the English systems thinker Arthur Koestler helped in the development of his architectural outlook. Koestler was the founder of the term "holon" in systems thinking, which points to a property of an open system.[151] The word is derived from the Greek *holos*, which is the equivalent of the word "whole". The term indicates that an open system works according to the equilibrium framework and is comprised of sub-constituents that behave in a hierarchically interrelated web, like a tree structure.[152] Furthermore, as Bertalanffy has suggested before him, not only biological systems, but also mechanical, economical and social systems also operate in a "holon" way. Koestler invented the term as a reaction against the reductionistic thinking that considers the parts of a certain organization as independently-operated phenomena. The tree-like organizations appeared especially in the Metabolist urban proposals. For instance, Kiyonari Kikutake's floating mega-structures, in which the dwellings protrude around a vertical reinforced-concrete supporter, were supposed to grow in a tree-like scheme.

Kurokawa points out that his symbiotic architecture, which he informed as being nurtured from the systems outlook to nature, is also in close accordance with Asian religious philosophy.[153] Indeed, as it was mentioned in the third chapter, systems sciences and Asian religious philosophies are in close accordance, as both deal with the internal configuration of energy currents as it flows from one context into another. He emphasizes that especially the Buddhist canon of impermanence motivates him when the man and nature relation is concerned. According to him, it suggests that every living entity temporarily exists in the universe, as they conform to the cycle of life and death:

> Buddhism teaches the impermanence of all things. All things in the world, including nature, are always changing, and we must awaken to the ephemeral nature of life. People, animals,

[151] Jo Wyns, 1994, "History of Holons", http://www.mech.kuleuven.be/goa/hms-int/history.html, (accessed Jan 2006).
[152] Arthur Koestler, 1969, "Some General Properties of Self-Regulating Open Hierarchic Order", in http://www.panarchy.org/koestler/holon.1969.html (accessed January 2006)
[153] Kurokawa, 1992, p. 16.

> plants, the rest of nature, and the Buddhas themselves are migrating within one great chain of life. Human beings, of course, exist within that ever-changing process of migration. In that context, the ideal that human beings must strive for is not to conquer nature, not to hunt their fellow animals, but to live as a part of nature, in accord with its rules.[154]

Indeed, the demountable units of habitation that were attached to the vertical cores of the Metabolist skyscrapers seemed to stand for the Buddhist principle of impermanence. Therefore, the idea of conformance to the cycles of life and death was present in the Metabolist architecture. As mentioned earlier, Archigram also benefited from the idea of impermanence as well. They developed modular and demountable structures in order to conform to the instant change in the urban structure. Yet, Kurokawa mentions that their architecture followed the Japanese cultural roots in conformity with the principle of impermanence, as Japanese architecture is developed in parallel with to the canon of impermanence:

> From ancient times, the Japanese have built their homes as if they were temporary shelters, and they have adopted a lifestyle of symbiosis with nature based on the teaching of Impermanence.[155]

Hence, Metabolists followed their contemporaneous in their envisioning of built entities as sufficiently operating for the conformance to the cybernetic urban environment. Although they aimed to unite man and nature in a symbiotic platform, their ambitions always stayed in the level of analogy. Their products became instruments of the information exchange by means of their expressive peculiarity, rather than being ecological one. Recently, the member Kurokawa is involved with locating his architecture to an ecological basis. For instance, his latest urban design for the city of Astana in Kazakhstan stands out for his environmentally-sound attributes.[156] With the passive and active technologies proposed, its water and waste management centers, rooftop greenery, the city is supposed to be the emblem of

[154] Kurokawa, 2004.
[155] Kurokawa, 2004.
[156] Kisho Kurokawa, 2004, "Interational Competition for the Master Plan and Design of Astana, Kazakhstan", http://www.kisho.co.jp/WorksAndProjects/Works/guangzhou/index.html (accessed January 2006).

symbiotic urbanism (Fig.3.22). As information, passive systems indicate the ones operating without any need for mechanical and electrical set-up. Accordingly, Kurokawa's favoring of such words "metabolism" and "symbiosis" seems to affect his Japanese colleagues who prefer to set forth the green attributes in their designs in the low-rise level. This issue will be the subject-matter of the subsequent chapter.

Fig. 3.22. *Kisho Kurokawa,* Interational Competition for the Master Plan and Design of Astana, Kazakhstan, *1997.*
Source: Kisho Kurokawa, 2004, "Interational Competition for the Master Plan and Design of Astana, Kazakhstan",
http://www.kisho.co.jp/WorksAndProjects/Works/guangzhou/index.html (accessed January 2006)

3.1.4.3. Soleri's "Arcologies"

Among the figures that came through with their visions on urban systems of feedback, Italian architect Paolo Soleri is the one who was mostly involved with the ecological-subject matter. His search for the environmentally-appropriate built environment gave way to imaginary cities, which were supposed to operate self-sufficiently in world ecosystems. He briefly explains his journey to cybernetic urbanism in the book entitled *The City in the Image of Man* in 1969.[157] In the book, he puts that his proposals were developed through a consideration of the built world as a part of natural environment, while being aware of the fact that human ecosystem cannot totally contribute to the system of nature. According to him, although the natural and the man-made behave differently in reality, architectural products should conform to nature's laws during the process of energy exchange. "Architecture is the physical form of the ecology of the human, that configuration of matter which allows for the best energetic and willful flux"[158], he writes.

Hence, man is dependent upon nature, while nature is an independent phenomenon. Furthermore, he believes that architectural creation should be endowed with the efforts to capture proper expressionism. Like Buckminster Fuller before him, Soleri believes that human cognitive capacity is the real wealth of humanity that helps to resist entropic degeneration. Like energy, human cognitive capacity cannot be diminished; rather, its quality may change irreversibly. The progressive development of human mental reasoning, coupled with the feedback control, is the means to resist entropic degradation. Hence, aesthetic creation, being one of the emblems of human cognition, has to power to enhance the quality of human mental reasoning. Architectural products are the means of knowledge exchange through transmitting information to future generations, therefore, the means to enhance the quality of cultural knowledge.

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[157] Paolo Soleri, 1969, *The City in the Image of Man,* Massacchussets: The MIT Press.
[158] Soleri, 1969, p. 7.

According to Soleri, cities have a substantial role in sustaining nature's equilibrium. "The city is a human problem that has to find its answer within ecological awareness"[159], he writes. Therefore, its proper configuration may enhance environmentally-sound patterns of living. Indeed, Soleri has certain suggestions for an environmentally-conscious urban environment. First of all, the city should operate in a manner that is similar with the one of a living entity. The living elements are bound to each other in a holistic network of relations. Similarly, the built elements of an urban structure should be designed by giving emphasis to the "congruence between the part and the whole"[160]. Hence, "congruence" is the first principle in an environmentally-conscious urban design.

Furthermore, a living entity survives in nature with the help of its feedback system. The same condition should be the standard for an urban structure. Therefore, the "cybernetic development" is the second principle:

> The concept of a one-structure system is not incidental to the organization of the city but central to it. It is the wholeness of a biological organism that is sought in the making of the city, as many and stringent are the analogies between the functioning of an organism and the vitality of a metropolitan structure. Fundamental of both is the element of flow. Life is where the flow of matter and energy is abundant and uninterrupted. With a great flow gradient the city acquires a cybernetic character.[161]

There are various ways to enhance cybernetic development in a built environment. As Soleri informs us, one of them is the mechanical support. He believes that the built entities that make up of the urban structure should be controlled by mechanical systems in order to enhance feedback activity. In this manner, the built environment becomes "truly machines for living".[162] Another one is, as he puts, to configure urban form under denser development. An urban form should develop into a compact configuration; that "miniaturization", which according to him is "the process of

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[159] Soleri, p. 7.
[160] Soleri, p. 5.
[161] Soleri, p. 13.
[162] Soleri, p. 14.

fitting more constituent into less in proportion"[163], should be the third principle for a proper human ecosystem. Furthermore, Soleri believes that this compact system would better take part in an efficient energy exchange if it is configured in a vertical structure. According to him, the vertical architecture is where the feedback of information is mostly experienced.

Among urban proposals that are configured according to the systems principles, Soleri emphasizes that his proposal operates more efficiently due to its compact peculiarity. He criticizes "Ecumenapolis" in particular, which is an urban scheme developed by the Greek urban planner Doxiadis in the 60s according to the systems principles. The main idea of Doxiadis' proposal is the unification of the world cities into a superorganic configuration. According to Soleri, it is difficult to achieve feedback control of an urban scheme in which its elements are dispersed in horizontal direction. He believes that the energy exchange systems are also a phenomenon in an urban environment, as it is in nature. A compactly-configured life form can achieve more efficient energy transformation when compared with the dispersed entity. Therefore, compactness is essential. "Swiftness and efficiency are inversely proportional to dispersion"[164], he writes.

Soleri put the aforementioned principles into practice in his 30 proposals for the future urban system, under the name of "Arcologies" in 1969. Coined under the combination of the words 'architecture' and 'ecology', "Arcology" is, as he informs us, the "one-structure system of human ecology"[165]. It is a man-made urban environment that operates like an organism and that is controlled through feedback systems. Basically, arcologies were symmetrically-configured built forms that were supposed to house one thousand five hundred to six million inhabitants, depending upon their scale. Geometry dominates morphological configuration; that "cube, cylinder, sphere, tetrahedron"[166] are the basic forms that make up of the Arcologies. Soleri followed Fuller in his bias towards triangular shaped geometries for the reason

[163] Soleri, p. 31.
[164] Soleri, p. 14.
[165] Soleri, p. 31.
[166] Soleri, p. 9.

that they are the most efficient both in structural stability and in energetic transformation inside the structure. Furthermore, according to Soleri, the fact that Arcologies could develop towards vertical direction enables the appropriate context for construction. Hence, he puts that they can be built anywhere and can be part of any natural ecosystem; ocean, earth and space. As mentioned earlier, the systems architectural theoretician Russell writes that considering the context of production was always ignored in the process of appropriating the systems principles to the discipline of architecture. Soleri seems to conform to this condition and considers his Arcologies as solitary entities that function according to their internal configuration, regardless of the context of development. "Arcology is a space architecture as much as it is a land and sea architecture"[167] he writes (Fig. 3.23).

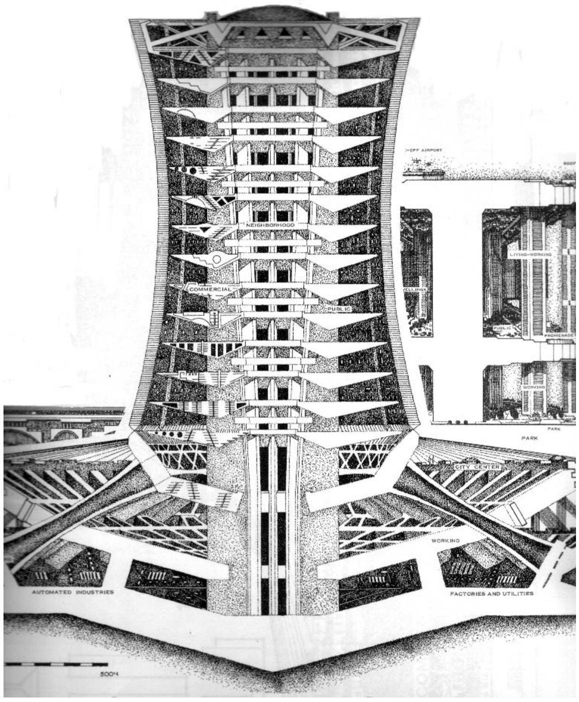

Fig. 3.23. *Paolo Soleri,* Babel IID, Arcology, *1969. Section.*
Source: Paolo Soleri, 1969, *The City in the Image of Man,* Massacchussets: The MIT Press, p. 69.

[167] Soleri, p. 31.

Indeed, the most painless form of development is the outer space. Soleri continued his vision for a compact future with the "Astereomo", which, as Soleri informs us, is an Arcology with seventy thousand people on "a double cylinder kept inflated by pressurization and rotation on its main axis".[168] It was a cybernetic development with a proper technology that is meant to efficiently recycle energy and resources (Fig. 3.24).

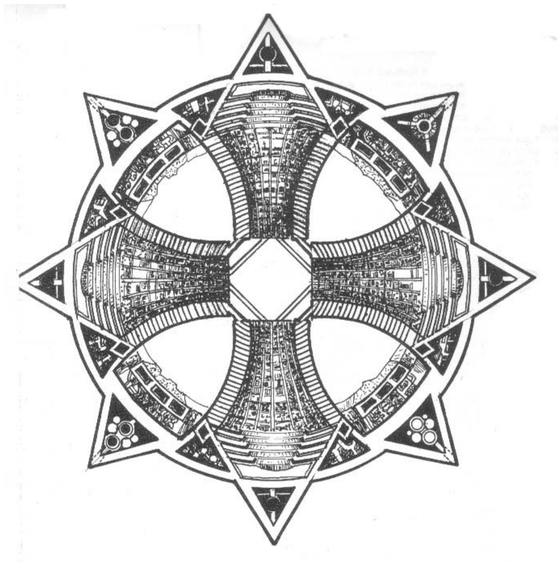

Fig. 3.24. *Paolo Soleri,* Asteromo, *1969. Plan.*
Source: Source: Paolo Soleri, 1969, *The City in the Image of Man,* Massacchussets: The MIT Press, p. 118.

Soleri is fascinated with space exploration. He puts that the degree of environmental exploitation renders space habitation as means for the future human survival. Furthermore, space exploration strengthens his belief in God. Soleri's autobiographer Adriana Antonietta Lima compiled Soleri's ideas, which is put forward in the following, regarding the subject-matter:

[168] Lima, Adriana Antonietta, 2003, *Soleri: Architecture as Human Ecology.* New York: The Monacelli Press, p. 340.

> The aesthetogenesis of the cosmos cerates high stakes, a play from which it is impossible to escape. Under the pressure of scientific and technological progress, stimulated by pressure from the outer space venture, the eschatological question will trigger new, or seemingly new, theological models, because I am inclined to think that life's space exploration is not so much a technological and economic undertaking as it is a theological one. [169]

As mentioned in the second chapter, Donald Worster, the historian of ecology, puts that systems science harbors the spiritual means of looking at scientific phenomena, which reached its peak when James Lovelock, the founder of the Gaia hypothesis, announced the superorganic properties of our planet earth that conditions its inner nature, free from human will. Indeed, like Lovelock, who considers natural environment operating in a large-scaled organic system, Soleri assumes his Arcologies as "man's superorganism". Soleri puts that an urban organism should condition its inner nature as well. He believes that teleological paradigms have a substantial place in shaping our urban future. Hence, he followed his colleague Fuller in locating his philosophy into a spiritual one, within a holistic outlook. Furthermore, religious patterns are the means to put forward the aesthetical counterparts of human ecology; hence the urban environment is the place in which this "aesthetic neonature" finds its morphological aspect.

In the 80s, we observe a fundamental change in Soleri's position from the technisict, to the regionalist one. His "Arcosanti" project in particular, conforms to none of the principles announced by him as the means towards human development through the aid of technology. His change of vision might be because of the unfeasibility of realizing his aforementioned vision due to the current economical conjuncture. His shift of vision will be explained in the subsequent chapter.

Until now, it is discussed about how systems thinking helped architects of the 60s era in setting forth technological paradigms. It was argued that the technicist/rationalist side presupposed architectural system as being subject to energy exchange, therefore referred to the principles mainly belonging to the theory of open systems. The built

[169] Lima, p. 351.

matter was assumed as a total system with its hardware and software. As mentioned earlier, the social activist wing on the other hand assumed architecture as being developed by means of information exchange between individuals, therefore might be interested mainly in the theory of information, which was considered by the systems scientist Bertalanffy as one of the canons of systems theory. The following paragraphs will be about those who set forward the social activist side of the systems architecture in the 60s.

3.2. The Social Activist Perspective: The Role of Architecture in the Information Exchange

As mentioned in the above paragraphs, the theory of information assumes that entropy is decreased by the continuous sharing of knowledge. Similarly, architects that favor social activism promoted interaction to impede loss of communication between diverse actors of the society, in the period leading to the appropriation of systems thinking in architecture. They conceived construction as a way of organizing different actors that involve in the process. The building making was considered as a social activity, and democratic methods were invented for the involvement of users with design and construction.

There were diverse efforts to reflect social attitudes to architectural practice. For instance, one of them was the self-build activity, which inaugurated by the youth groups of the late 60s that protested against ravages of war for the reason of its causing environmental exploitation. As mentioned in the Introduction Chapter of this thesis, the theoretician of architecture, John Farmer, exemplified the following effort within the social reaction against the post-war destruction of natural environment.[170] The followers of such attitude developed units of habitation to encourage community activity; with the materials collected from nearby environment and with or without

[170] John Farmer, 1999, Green Shift: Changing Attitudes in Architecture to the Natural World, 2nd ed., Oxford: Architectural Press.

taking professional aid. The most famous example of the self-built activity was the formation of the Drop City in the southern Colorado in 1965.[171] It was initiated as a social experiment. Later, it was transformed into a "hippie" commune by artists and student inhabitants that sought social change. The dwelling units were developed out of a system of triangular panels made from the sheet metal of automobile roofs. The architectural system was inspired from the geodesic domes of Buckminster Fuller and thus won the Dymaxion award of Fuller in 1966. The structural system were endowed with such materials as beer bottles, urethane foam or more natural materials such as earth, timber and canvas. (Fig. 3.26).

Fig. 3.26. Drop City in Colorado.
Source: "Drop City", www.hippiemuseum.org/ dropcity.html, (accessed March 2006).

The other means of reflecting communal issues was related with the architects' endeavor. Here, the architect gathered diverse social groups from different professions and designed with the aid of their criticism and response. The architect eschewed from reflecting individual expression and gave only place to the opinions of the community. Like the self-built activity, the communal design had also the mission to promote collective action. An example for the design through social

[171] For further information see the following website:
http://parole.aporee.org/work/print.php?words_id=776

diversity might be Cedric Price's method of working, which was accepted as one of the means of practicing architecture through systems approach by Steven Mullin, whose article appeared in the 1967 issue of the *Architectural Design* Journal, edited by Rabeneck.[172] Mullin mentions in his article that it was a common practice for Price to arrange meetings, lecture visits and chats for a "short-term pattern of exchange" with individuals or organizations, such as, "politicians from left and right, industrialists, trades union officials, educationalists, anti-educationalists, artists, anti-artists, and architects of every shape and description could never conceivably from a homogeneous group".[173] However, Mullin writes on the disadvantages of working with movements and groups with respect to the quality of design. He puts that the architect's endeavor in bringing forward his professional skill is declined in socially diverse groups. In such a system, the architect prefers to concentrate on the social enhancement, rather than the artistic one. Mullin mentions about the disillusionment of an architectural student about one of Price's works. The student found the work as being lack of aesthetic style without thinking of, in Mullin's terms, "whether the building was a humane answer to the occupants' needs".[174]

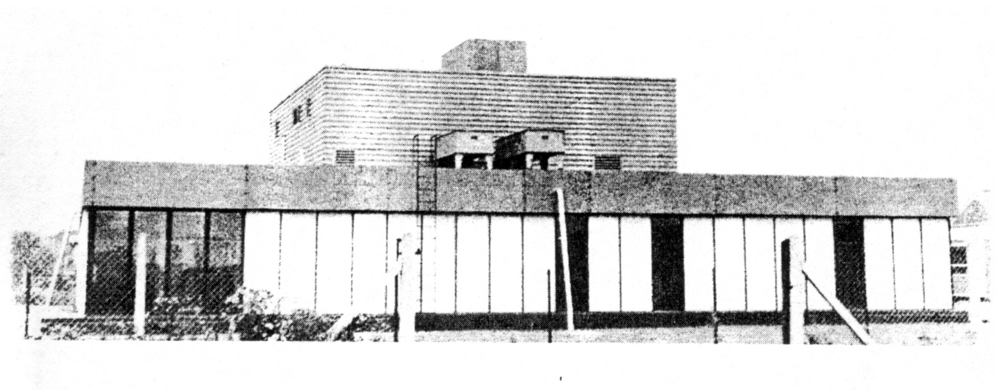

Fig. 3.27. *Cedric Price,* British Airports Authority Office Block, *1967.*
Source: Steve, Mullin, 1976, "Cedric Price or Still Keeps Going When Everything Else Has Stopped", in Andrew Rabeneck (ed.), "Whatever Happened to the Systems Approach?", *Architectural Design*, Vol.46, pg. 283.

[172] Mullin in Rabeneck, 1976, p. 275.
[173] Mullin in Rabeneck, p. 276.
[174] Mullin in Rabeneck, p. 276.

Another performance which reflected the community opinion, and which was commonly used in the systems research and analysis, was taking response from the future users of the building beforehand the design, without letting them involve with the design activity itself. Here, the architect, through surveys, collected the needs and requirements of the building users and designed accordingly. Though this method was seen as part of humane means of designing, indeed it is part of a usual procedure followed by technocrats in order to control, as the systems theoretician Handler suggests, "…the effectiveness with which buildings and their components achieve desired results through their behavior"[175]. As information, feedback controls were the means of observing whether an organization works despite the constraints set by the environment. Hence, performance criteria were one of the means in systems architecture to check whether the design was accomplished by conforming to the constraints set by the users.

3.2.1. The Advent of Vernacular as a Form of Social Enhancement

The other means of systems activity on the side of social activist mission, as Russell comments, was concerned with "the social place of the building"[176]. Here, the architectural object is not the direct product of a collective activity, however, represents the collective culture via its visual attributes. By representing the physical conditions, social values and norms of a particular region, it offers a basis for the sharing of cultural knowledge between inhabitants. The architect Herb Greene writes in his book *Mind and Image* that a built object has a role in carrying of culturally derived codes. When constructed in a particular region, they "may enable the consciousness to participate in the experiences, lived or imagined, of particular peoples".[177] (Fig. 3.28.)

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[175] Handler, 1970, p. 28.
[176] Handler, p. 692.
[177] Herb Greene, 1976, *Mind and Image: An Essay on Art and Architecture,* the University Press of Kentucky, p. 37.

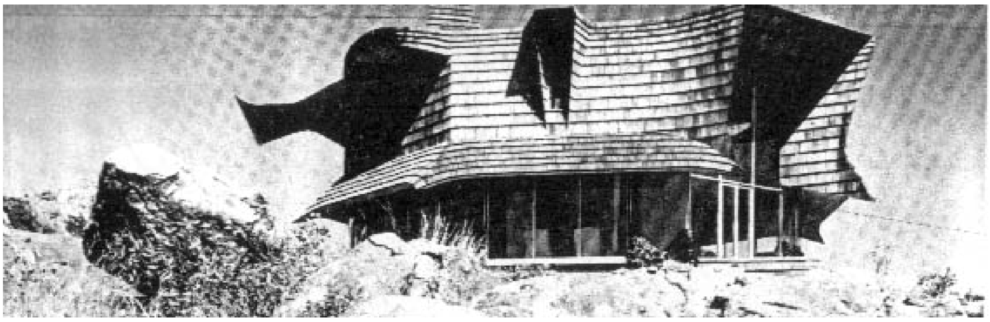

Fig. 3.28. *Herb Greene,* Joyce Residence, *1958-59.*
Source: Herb Greene, 1976, *Mind and Image: An Essay on Art and Architecture,* The University Press of Kentucky, pg. 105.

Accordingly, as aforementioned earlier, Russell believes that designing according to the cultural context in which the building is situated should be considered as the genuine means of practicing systems theory in architecture.[178] He writes: “A building is not only of concern to those who use it directly, but to those who see it and for whom it forms part of a total environment”.[179] According to this vision, a building is the sub-system in the larger set of physical and cultural systems. While Russell announces us the necessity of being in a contact with the larger context of relations, his contemporaneous Greene, in his book *Mind and Image*, give clues on how to obtain that contact. According to him, there are two ways of developing a relationship between an architectural artifact and its environment. One is in terms of physical contact, stemming from “the ecological relationships of the climate, soil, plants, and animals of the earth’s regions”.[180] The other aspect of the environmental contact, according to Greene, is the symbolic link:

> Another aspect of site relationship is the symbolic link certain objects and ideas have with particular places and regions. The ancient artifacts of a place, like the legends attached to it, can constitute valued evidence of the lives of previous inhabitants. Such evidence can also be found in the folk buildings or other architectural forms that may have resulted from physical

[178] Russell, 1981, p. 694.
[179] Russell, p. 694.
[180] Greene, 1976, p. 85.

> cooperation with a site. It can be found in landforms, rivers, and other natural features that have become associated with historical events. Buildings and natural features acting as signs of valued past experience permit a communion-vague, perhaps, but beneficent-that can help to bind together a social group and enable people to feel that they are part of a historical process larger than their immediate lives.[181]

Hence, according to Greene, the best way for an architect to enhance social relations is both providing an ecological means of connection with the region, and presenting the cultural codes and norms embedded in its history. As we learn from John Farmer, who was the historian of green architecture, that the 60s interest in the folk building types began with Bernard Rudofsky's exhibition entitled *Architecture without Architects* in 1967.[182] Accordingly, in his book that endow the similar name with the exhibition, Rudofsky criticizes the contemporary association of historic architecture with the noble types of buildings, such as palaces, commercial and official types or the houses of gods, or, in his words, of "the merchant princes of bloods", and with those which were built later than the first fifty centuries.[183] His aim is to challenge the conventional ignorance of folk types and prehistoric ages in architecture. Rudofsky emphasizes that the primitive buildings display the "humanness" of architecture because they don't reflect the ego of a single architect; rather, they emerge through a collective action.[184] He believes that buildings which stem from the shared knowledge of social actors are as significant as those which have a stylish impulse, in terms of preserving our common heritage (Fig. 3.29).

[181] Greene, p. 85.
[182] Farmer, 1999, p. 11.
[183] Bernard Rudofsky, 1964, *Architecture without Architects,* New York: Doubleday and Company Inc., p.1.
[184] Rudofsky, *Architecture without Architects,* p. 4.

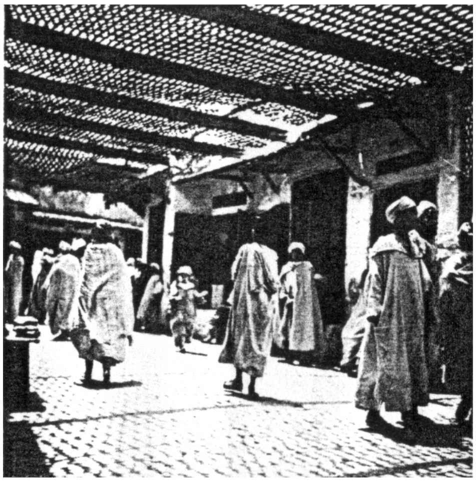

Fig. 3.29. Rudofsky's architecture of humanness. The arcades of Morocco.
Source: Bernard Rudofsky, 1964, *Architecture without Architects,* New York: Doubleday and Company Inc., p. 82.

Accordingly, John Farmer points out that the interest in the folk traditions marked the development of green architecture, alongside the other social activist architectural activities, such as the self-built practices with the garbage products.[185] Moreover, he informs us that there is a close alliance between the primitive means of building construction and the self-built activities of the more civilized cultures, as they both are the ways of bringing forward kinship relations. He puts that the civilized cultures refer to archaic building methods in order to regain the lost contact between individuals due to the modern urban conditions of living. According to him, the architectural practice of both the archaic and the hippie cultures resemble "in the putting together what is available".[186] He insists that the only difference between the works of both cultures is the materials they used. Leaves, woods stones and clay materials in the former are replaced with industrial wastes in the latter. Farmer writes the following:

[185] Farmer, *Green Shift,* p. 15.
[186] Farmer, *Green Shift,* p. 15.

> Now again the urge to re-examine the fundamentals of human need, to strip away the superfluous in the cause of saving the earth is strong. For some this will be a return to folk ways combined with the use of our scientific know how, for others a purer return to the primitive. With the concern for the earth that was emerging in the 60s now becoming widespread, folk ways are again being looked for guidance. In architecture the fitness, utility and material spareness of much folk building is stimulating as we explore how to regain in our buildings a balance between ourselves and our resources, between humankind and nature.[187]

Greene and Farmer prefer to identify the pre-industrial cultures as 'folk', and the buildings that are constructed through an appeal to these cultures as 'folk buildings', while most people dealing with this topic prefer to identify the traditional lifestyles and building methods of archaic people as 'vernacular'. As mentioned by John Farmer, vernacular styles became an issue in the modern urban setting after the architects reiterated the Romantic appeal to the primitive cultures in the 60s. Then the question is; what are the ways to identify an architectural product as vernacular? The theoretician Victor Papanek, in his book entitled *The Green Imperative*, gives six explanations about the subject-matter.[188] His first assumption is that a vernacular building can be identified from the technique used during construction, which, according to Papanek, is the combination of material, tool and process. The technique diverts according to the diversity of the region. For instance, as he informs us, the technique used to construct a log cabin in an American setting is the combination of "round log" as a material, "axe" as a tool, and "the chopping of curved lumbers at the ends" -"kerf-cut" in local terminology -as a process. Papanek points out that there are manifold vernacular techniques resembling this sample in the world.

Accordingly, such architect being involved with this type of vernacular means of construction was Walter Segal.[189] He developed a trademark of his own by combining traditional timber framed structures with the various kinds of

[187] Farmer, 1999, p. 15.
[188] Victor Papanek, 1995, *the Green Imperative,* London: Thames and Hudson, pp. 118-138.
[189] The information on Walter Segal was obtained from John Maule McKean in Rabeneck (ed.), pp. 288-295.

manufactured materials, such as wood wool slabs, plasterboard sheets and asbestos cement.[190] He, in a way, brought together the primitive and the industrial in a building system. Informingly, Segal's construction system never changed although the building type was different in every application. Moreover, as the trademark system was used in every design regardless of the building type, there was no need to repeat the structural calculations every time it was applied. The organization of built components, akin to the one in SCSD group, allowed the integration of mechanical, lighting and electrical equipment. The timber framed system was assembled in situ the selected area and was open to self-built by everyone because the method of combination is standard.

Accordingly, Andrew Rabeneck informs us that Segal developed his building hardware system with the aid of his interest in systems view.[191] Furthermore, according to his autobiographer John Maule McKean, Segal appreciated systems view for the reason that it offered a way of designing building elements in relation to the whole organization.[192] As it was mentioned with a reference to the systems theoretician Benjamin Handler, the 60s systems architects were mainly interested in hardware configuration and it's supporting software methods of design; rather than energy exchange and climatic considerations. Hence, like his contemporaries, Segal was mainly interested in the building itself; how its materials can be configured in relation with the entire structure. Moreover, he also put emphasis on the energy relationships that was one step forward to understanding architecture as a holistic phenomenon in these years. He arranged the siting and orientation of his buildings according to the climatic configuration in which they were situated. Hence, Segal's integration of the rationalist-based systems design methodologies and the vernacular mode of production was what made him unique among other architects.

Segal's involvement with systems approach did not indicate that he strictly followed every principle that is needed to pursue an appropriate systems research and analysis.

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[190] McKean in Rabeneck, 1976, p. 291.
[191] Rabeneck, 1976, p. 290.
[192] McKean in Rabeneck, 1976, p. 290.

For instance, Segal eschewed from interdisciplinary connections and from being involved in organization groups; rather, he designed on his own. Segal was described by McKean as a "one-man office-no secretary, no assistants".[193] Even his relations with the client were predetermined. He permitted the client to modify the design if only he/she operated within the limits that the structural system allowed. We learn from McKean that Segal also avoided from being involved with complex type of buildings, which might necessitate comprehensive research processes that might be essential to deal with the scale of the problem. Marvin Adelman once mentioned that the breadth of systems analysis is bound up with the complexity of the problem posed. Here, we understand that Segal narrows the depth of systems research and develops a method of his own (Fig. 3.30).

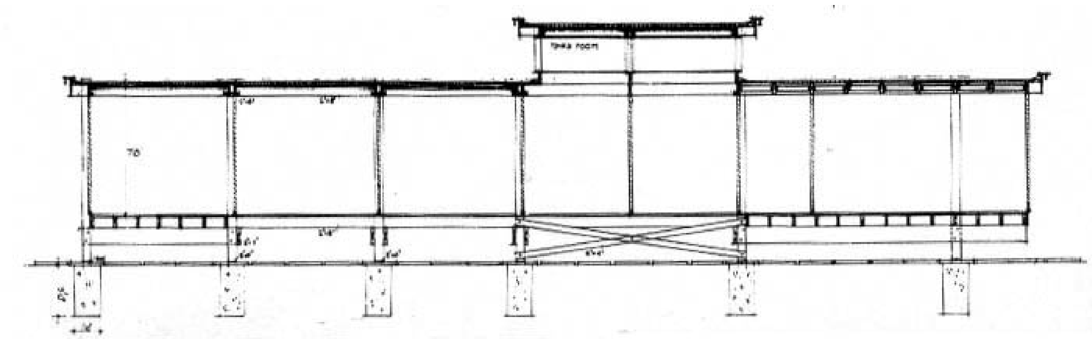

Fig. 3.30. *Walter Segal,* Children's Home, Sussex, *Elevation.*
Source: John Maule McKean, 1976, "Walter Segal", in Andrew Rabeneck (ed.). "Whatever Happened to the Systems Approach?" *Architectural Design*. Vol.46, pp. 289.

[193] Steve Mullin, 1976, "Cedric Price or Still Keeps Going When Everything Else Has Stopped", in *Architectural Design*, vol.46, p. 283.

3.2.1.1. On the Vernacular Type

According to Victor Papanek, the second means to identify a vernacular building is through looking at the relations of the building with its context. As he informs us, there are two means to understand the relation. One method is analyzing the human material relations of a particular geography. A building constructed by a lower class can be the vernacular imitation of a building constructed by a higher class. The other method is finding the morphological correspondence of two buildings that are situated in the identical climatic zones. A vernacular building can have a formal structure, which is identical with a building that is situated in a different region with identical climate. Papanek informs that this method was discovered by the structural botanists who identified similar morphological structure in the plants that are erected in diverse regions having identical climatic peculiarities. However, according to Papanek, both materialist and climatic relations are not solely sufficient to determine the contextual situation. He puts that "living patterns, perceptions of space, culturally determined settlement structures, traditions"[194] are also crucial in the cultural context. Therefore, this explanation, according to him, is "reductive".

It is noteworthy to add that while Papanek's first principle considers the vernacular as a single entity that should be analyzed with regard to its integral configuration; his second principle locates the vernacular to a socio-cultural context. Accordingly, whether a vernacular object should be thought as a thing-in-itself or a thing in the general contextual setting will be the concern of the later paragraphs. In the later paragraphs, it will be seen that the discourse on vernacular is also embedded with this systems idea that censures capturing any phenomenon by isolating it form the context of setting. Systems approach put that focusing on a particular entity might avert us to capture the general framework of a certain totality.

[194] Papanek, 1995, p. 126.

Papanek's third principle again put emphasis on the singularity of the object, rather than the object and its environment. The "evolutionary explanation" in particular, is about the documentation of the timely evolution of a particular building type. The general idea is that a particular form might help to understand the general cultural framework; therefore, an analysis on the evolution of a particular form might help to document architectural culture at the same time. However, Papanek warns those who try to set forth the change in the morphological structure of a vernacular type. Firstly, he emphasizes that when compared with the artifacts belonging to more civilized cultures, the speed of change in the formal configuration of a vernacular building is very slow. According to him, vernacular types are well-known for their resistance to change; therefore analyzing types may not render to comprehend the timely evolution of the building practice. He is suspicious about how a vernacular type, which is slowly evolving in time, can give us clues about cultural evolution, which has more an accelerating rate when compared with formal evolution. Second, he is against to make generalizations from partial constructs; therefore, for instance "house types cannot give a true picture of the history of house building".[195]

In this sense, the "evolutionary" explanation gives emphasis on the formal configuration of the artifact for its having a representational value, rather than on the artifact and its social and physical surrounding. Moreover, this principle also in a way contradicts with the consideration set forth by Herb Greene and Barry Russell being mentioned earlier; that the social and physical setting is what makes a vernacular architecture, rather than the singularity of the object.

3.2.1.2. The Role of Vernacular Forms in the Information Transfer

The theoretician of architecture Louis Fernandez Galiano, in his book entitled *Fire and Memory*, discusses the role of built forms in documenting cultural development

[195] Papanek, 1995, p. 126.

with the help of the systems sciences.[196] In the book, he sets forth the hypothesis that architectural forms conserve the knowledge on construction inside their structure. Therefore, buildings serve the purpose of transmitting this cultural knowledge to the future generations. To argue on the idea, he refers to the Spanish ecologist Ramon Margalef, whose studies were mentioned in the second chapter.

Margalef was well-known for his studies on the communication of organisms in an ecosystem. He argued that not only energy, but also information is also exchanged between organisms in order to reach ecosystem stability. For instance, how to operate metabolism is a particular knowledge of survival learned through time. The information on endurance is transmitted to the subsequent generations through a communication network. As it was cited by Galiano in his book, according to Margalef, "information and form always appear in relation with historic development"[197]. The subsequent generations learn from their ancestors the knowledge on stable development in this respect. Margalef referred to Claude Shannon's information theory as a supporting argument of his ideas. His hypothesis unifies the theory of open systems and of information. Furthermore, as Galiano informs us, Margalef emphasizes that the same kind of information exchange can also be found in human relations[198]. The man-made artifacts conserve the results of human information network in their structure. Like organisms, human beings learn to maintain stability from past experiences as well.

Thus Galiano, with reference to Margalef's theory, assumes that the practice of making buildings develops through human information network. The builders of the present age transmit knowledge to the builders of later ages.[199] The built forms are "the channels of information" in this respect; they possess knowledge on construction.[200] Architectural forms preserve information about our historical

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[196] Luis Fernandez Galiano, 2000, *Fire and Memory: On Architecture and Energy,* Cambridge: The MIT Press, pp. pp. 62-78.
[197] Margalef, in Galiano, 2000, p. 64.
[198] Margalef, in Galiano, 2000, pp.55-56.
[199] Galiano, 2000, p. 64.
[200] Galiano, p. 62.

existence. Therefore, as Galiano puts, architectural culture is directed by the similar type of conservatism argued by the ecosystem ecologist Margalef. Galiano writes:

> As we see, energy is stored as form (material organization of space) and as information (mental organization of space) without distinction; this accumulation of energy can increase efficiency, as much in the use of space as in its reproduction. In architecture, the accumulation of energy as form/information is expressed in phenomena such as the persistence of certain spatial organizations through time. The tenacious survival of urban schemes or building typologies, the rare consistency of some formal layouts, and the continued adherence to certain construction solutions are evidence of the existence of a morphological memory: a memory that does not rest only in the heads of builders, inhabitants, or spectators, but is present as well in the architecture itself. [201]

As a result, according to Galiano, architecture is haunted by the idea that built forms possess information on cultural development. As mentioned in the earlier paragraphs, Victor Papanek is suspicious on this assumption because he believes that vernacular forms develop in such a slow rate that they are unlikely to give evidence on our historical evolution. Accordingly, Galiano is suspicious either. In his book, he puts forward that analogies between biological and cultural development do not have scientific evidence. With the help of those scientists who researched on the subject, he concludes that "…the genetic channel has the capacity to store and transmit a very small amount of information compared to that which can be channeled through such socio-cultural means as the language of architecture."[202] Cultural evolution has a more accelerating rate than biological evolution. The genetic code can hardly possess knowledge in quantifiable terms when compared with the quantity of knowledge possessed in the human codes and norms. Therefore, it is not possible to understand the progressive development of culture by looking at the evolution of organisms' genetic development. Galiano points out that we should be:

> …more cautious when making analogies between buildings (and other human productions) as supports of cultural memory and genetic material as the support of biological memory, or

[201] Galiano, p. 66.
[202] Galiano, p. 72.

> when comparing man's symbolic products, his different codes and languages-including architecture-to the gene tic code.[203]

Papanek points to the slower pace of vernacular progress when compared with the technological one. It seems that genetic evolution is more decelerated than both the vernacular and the technological evolution. Despite the scientific evidences, there is a desire to construct one-to-one correspondence between biological and cultural evolution in the discipline of architecture. Such desire is displayed in the article "Architecture of Architecture" that is written by the architects Bill Hillier and Adrian Leaman.[204] In the article, the writers argue that spatial organization has a universal language, the general structure of which can be determined by looking at the values and norms of pre-industrial societies. They write:

> The hypothesis is that the relation of human behavior and cognition to artificial space is governed by an evolutionary code, which explains both our modes of constructing space and the way it is intelligible to us. The morphology therefore exhibits the properties of social language.[205]

According to them, social norms endow the role of the "genetic code of organisms" in human cultural development.[206] Their theory points to what both Galiano and Papanek are suspicious about; that is, one-to-one correspondences between biological and cultural evolution. In the article, Hillier and Leaman analogizes the development and growth models of organisms with the ones of architectural culture. They suggest recording the evolutionary development of architecture through looking at the primeval means of form making.

Correspondingly, they argue that cultural development should be understood in evolutionary, rather than entropic terms. They point to the fact that the development models of Darwinian evolution and the ones of thermodynamic evolution are

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[203] Galiano, p. 74.
[204] Bill Hillier and Adrian Leaman, 1973, "The Architecture of Architecture", in *Models and Ssystems in Architecture and Building,* cambrdige: the Construction press Ltd., pp. 5-28.
[205] Hillier and Leaman, 1973, p. 9.
[206] Hillier and Leaman, p. 9.

different from each other. While Darwinian evolution suggests the progressive growth and complexity of living forms through the passage of time, the first law of thermodynamics suggests the progressive decay and simplicity of organisms, as they cannot resist entropy. A small reminder can be given here from Bertalanffy: he informed us that the theory of open systems united two different development models by suggesting that organisms are both subject to decay and complex development at the same time. In Hillier and Leaman's article, it is assumed that organisms are inevitably subject to entropy. However, the theory of open systems suggested that this condition did not put an end to organisms' development because they are protected from entropy with the aid of their homeostatic mechanisms inside.

A reminder should be given here about the scientific correspondent of the theory on which Hillier and Leaman figure out. The existence of gene was not proved scientifically in the period in which Darwin developed his theory of evolution through natural selection. Despite that, Darwin set-up the foundations of future experiments by theorizing that competitive struggles may well undergo between members of the same species, in which genetic variation occurs as the result. That hypothesis indicates that biological entities could modify their internal structure with regard to the outside environment and evolve that way. Another note should be given here; that contemporary scientific studies dispute the idea regarding genetic code being open to modification due to Nature's laws.[207] Recent experiments proved that there is a leader gene which determines the adaptation of other genes to the external conditions, rather than 'Nature'. Here, the leader gene selects a particular gene among the others in the gene pool. This selected gene has appropriate information on adapting to the outside conditions. The leader gene orients the selected gene for its transmitting the knowledge on survival to the other genes in the gene pool. For instance, if the survival within cold climatic conditions is of concern, the leader gene identifies the one which has the capacity to operate its antifreeze mechanism and drives this gene to share the knowledge with the other genes in the gene pool.

[207] The information about the current doctrines on evolutionary science is borrowed from Brig Klyce's article entitled "Neo-Darwinism: The Current Paradigm". See the following website: http://www.panspermia.org/neodarw.htm.

Therefore, evolutionary development occurs by the communicative network of the genes, rather than through Nature's internal mechanism. It is possible to claim that the exchange of ideas is always at place in every type of living systems; that evolution is not a mechanical process, but rather a communicative one.

Thus, Hillier and Leaman are on the side of Darwinian explanation while investigating the development of architectural culture. In this sense, while Darwinian assumption puts that it is Nature that determines the growth of species, in Hillier and Leaman's hypothesis, it is the social structure that determines the development of forms. In order to argue on their hypothesis, they analyze how primitive cultures configure their spaces. The most primitive form of space configuration, according to them, is "the indication of barrier", which is "the primary level at which the socio-spatial code expresses itself through the language of the morphology of artificial space."[208] They put forward how barrier configurations evolve from the simplest to the more advanced (Fig.3.31). After that, they continue putting forward how the acts of barrier indication evolve into dwelling patterns in the course of time (Fig. 3.32).

[208] Hillier and Leaman, "The Architecture fo Architecture", p. 10.

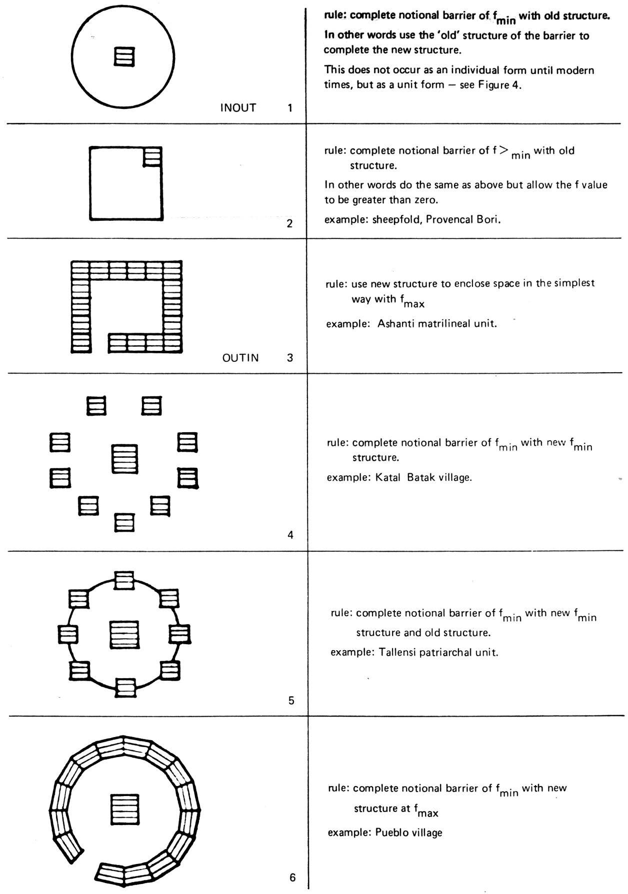

Fig. 3.31. Hillier and Leman's citation on the primitive spatial configurations from Banister Fletcher.

Source: Bill Hillier and Adrian Leaman, 1973, "The Architecture of Architecture", in Dean Hawkes (ed.), *Models and Systems in Architecture and Building,* Lancaster: The Construction Press Ltd., p. 15.

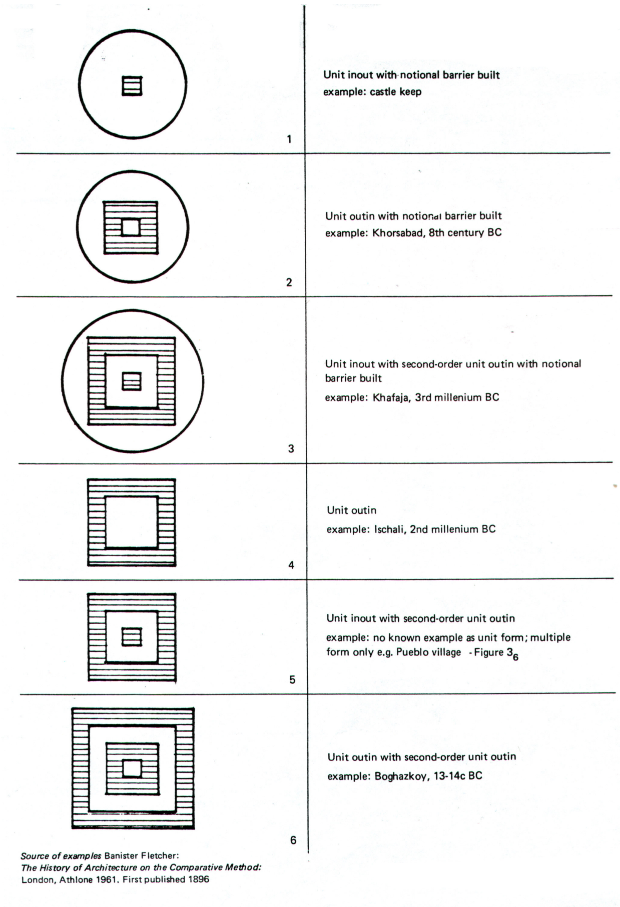

Fig. 3.32. Hillier and Leman's citation on the primitive forms of architecture from Banister Fletcher.
Source: Bill Hillier and Adrian Leaman, 1973, "The Architecture of Architecture", in Dean Hawkes (ed.), *Models and Systems in Architecture and Building,* Lancaster: The Construction Press Ltd., p. 15.

After analyzing on the evolutionary order of space configuration, they set forth the mathematical model of these forms. Their aim is to unveil how social codes support the development of morphologies. They make use of the French mathematician Réne Thom's method, to figure out the mathematical correspondence of architectural forms, which develop through social communication. They believe that locating the argument on a scientific basis enables to trace the further development of the culture of architecture.

In this respect, Billier and Leaman's article display the emphasis put on formal typologies under the consideration that they are the signifiers of cultural evolution. Here, we observe the borrowing of terminologies from biological sciences, under the assumption that both genetic and typological structures carry information leading to human development. Consequently, as mentioned earlier, the architectural theoretician Galiano taught us that it is possible to argue on the formal means of conservatism with a philosophical support not only from evolutionary science, but also from ecosystem science as well.

As mentioned in the second chapter, the difference between evolutionary and ecosystem view about the emphasis put on organic type is while the former considers it as a development model of a single entity, the latter considers it as the one of the totality of ecosystem setting. The post-war systems scientists put emphasis on a particular element if only it maintains the survival of the totality of ecosystem; that parts and whole interrelations are important for stable development. Ecosystem science is on the side of communal ethic in an ecosystem, in which organisms work together and communicate for its steady state. Their doctrines are in opposition to the individualist ethic of evolutionary view, in which organisms develop their own structural make-up.

As mentioned in the above paragraphs, the differences between the emphasis given to typological set-up in both ecosystem and evolutionary views are reflected to the architectural theories as well. In Galiano's case, which is closer to ecosystem approach, the form has significance if only it enhances communal means of social interaction, so the culture develops that way. In other words, the part has significance only it operates within the totality of the general structure. In Hillier and Leaman's thesis on the other hand, which is closer to evolutionary approach, the degree of development can only be understood by looking at the structural configuration of a single type; that the type has a representative value in its singularity, rather than a communicative value. However, as Galiano argued, the correlations between cultural and biological evolution is refuted within biological science itself.

3.2.1.3. The Duality between Individual Actions and Communal Practices

The previous remarks assert that in systems theory, a single entity has a value when it operates within a general framework. Similarly, an architectural form has cultural significance when it is the product of communal activity. Despite that fact, today, in green architectural discourse, typologies are still being referred with a support from Darwinian framework. For instance, Dean Hawkes, in his aforementioned book, claims that the green architecture develops if we invent certain green typologies and render them as a source ready to be utilized within every society in general.[209] For that, we have to follow Darwinian thesis and consider a singular type as a form of survival and develop its environment-appropriateness within the confines of this formal integrity. However, Papanek's ideas on the vernacular are indeed disprove this thesis. According to him, architectural culture develops if only architects practice by giving value to the context in which the object is produced. There cannot be a general typology or the combination of typologies which is sufficient enough to determine the universal language of space configuration. The reason is that spatial experience is different in every society because their everyday living patterns divert from one context to another. Consequently, his fourth principle indicates that if we want to consider a building as a vernacular artifact, we should firstly look at the cooperative activities of the society, such as communal means of space configuration, or everyday living patterns. Here, Papanek compiles pictures resembling Rudofsky's examples on architecture without architects and brings forward different means of vernacular production in tribal populations around the world (Fig.3.33).

[209] Dean Hawkes, *The Environmental Tradition.*

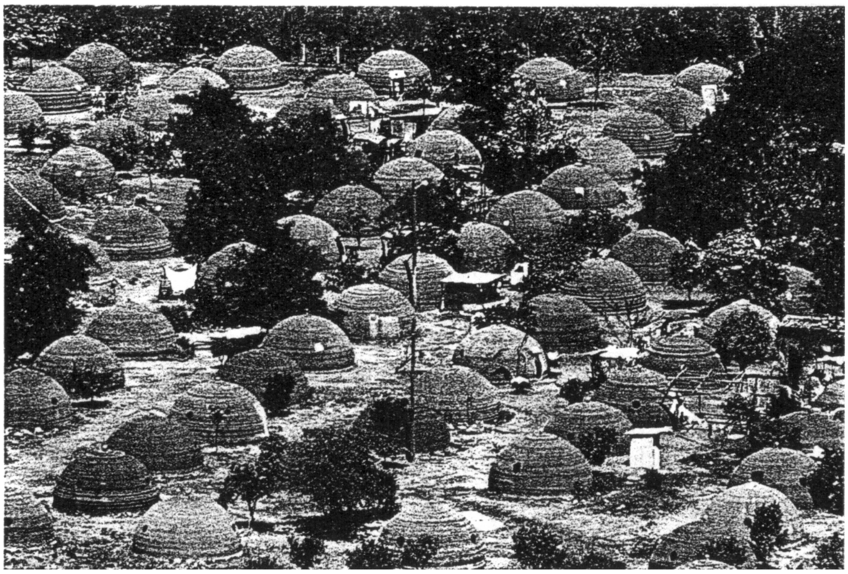

Fig. 3.33. Papanek's example on the vernacular: "Foam domes, post-earthquake emergency shelters of polyurethane, 1972, Nicaragua."
Source: Victor Papanek, 1995, *The Green Imperative,* London: Thames and Hudson, p. 56.

Moreover, as he points out in his fifth principle, not only artifacts created with the help of everyday practices, but also those developed through the philosophical information produced via these everyday lives are the indicator of the vernacular, such as the shared values and norms or symbolic patterns belonging to a particular culture. He exemplifies tribal artifacts created with the help from specific cultural philosophies, such as Feng Shui, a cultural construct belonging to Asian societies. As information, Feng Shui emerged as a philosophy with the help of the religious models of Asian societies. The general principle is that we should place an order to our environment by a particular emphasis on patterns of energy flow, which is believed as having a spiritual character in nature. The flows attained spiritual character through the course of time, by the social attainment of meanings to them. These meanings are produced under the support of religion. Indeed, energy flows has a particular significance in Asian religions. It is believed that our world is the result of continuous exchange of energy; therefore, the human patterns of order should be in conformance with these flows of exchange. In this respect, the ones who design accordingly should configure spaces in conformance with the direction of flows determined in the Feng Shui doctrine.

Similarly, in his article "Biology of a Cosmological Science", the biologist Harold Morowitz argue that Asian metaphysics provides the philosophical basis for the thermodynamic science, which is involved with the impact of energy flows on environment.[210] According to him, the central notion of Continental philosophy is that our world is a collection of phenomena shaped with the aid of energy patternings of universe. Likewise, thermodynamic principles also suggest that energy relations shape the earthly incidents. Moreover, Morowitz claims that Asian religious doctrines are influential to modern science especially regarding its ideas on the place of individual in an energy environment. It is believed that an individual in its solidarity does not have significance unless he/she is the part of the energy cosmos of the universe. He informs us that especially the science of ecology benefited form this idea in its studies on the patterns of energy exchange between living members on our planet. He exemplifies his thesis through Buddhist religion in the following:

> In a book entitled *Science and Buddhism*, P. Dahlke has elaborated the thesis that in theology everything stands, in science everything falls, and in Buddhism everything burns. The notion of burning is a metaphysical expression of transience and impermanence….Although the Buddhist syntax is entirely different from that of modern science, a notion is clearly present that everything is process-a process which only persists by virtue of some universal kind of energy flowing through the world. From this point of view, the reality of individuals is problematic because they do not exist per se but only as local perturbations in this universal energy flow. As originally presented, this must have been a very mystical idea, but a similar kind of idea seems to emerge from modern science. Everything we know of is indeed process, which is mediated on the surface of our planet by the flow of solar energy through all organized structures.

Moreover, the biologist Harold Morowitz argues in his article that Asian metaphysics has a particular impact on the paradigm shift in biological sciences, from Darwinian view that accentuate on the individual entity as the indicator of life, to ecosystem

[210] Harold Morowitz, in Baird Callicott and Roger Ames (eds.), 1989, "Biology of a Cosmological Science", in *Nature in the Asian Traditions of Thought,* State Uni. of New York Press, pp. 37-49.

view that gives emphasis in a cooperative action. Morowitz points out that the "object-centered view" declines in favor of "continuum view", when the ecological condition of our earth is of concern, because, as he puts, "species itself exists only in relation to an ecological niche within a biome, which includes other living organisms as well as geological factors".[211] He concludes the article with the following axiom: "The idea that man is part of nature is the ultimate Darwinian statement. The thermodynamic statement is that man is limited."[212]

The well known figure in the architectural discipline, who studied on the relations of spiritual flow patterns with vernacular architecture, was the Norwegian architect Christian Norberg-Shulz. He writes a book that was published in 1980 entitled "Genius Loci", which is the Latin correspondent of "the Spirit of Place". He argues throughout his book that architecture is the reason for the subsistence of human culture.[213] According to Norberg-Shulz, architecture is not developed through the meaning attached by the humanity; rather, it is a phenomenon itself giving meaning to human existence. His arguments are in a way the antithesis of Hillier and Leaman's arguments on the place of architecture as a signifier of culture. Norberg Shulz believes that socio-cultural systems exist if only architecture exists. Therefore, architecture has a phenomenological significance for its being always open to human experience and the collection of experiences is what makes culture. "The purpose of the work of art is to 'keep' and transmit meanings", Norberg-Shulz writes.[214] And the meaning is transmitted through the experience of the work of art (Fig. 3.34).

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[211] Morowitz, 1989, p. 45.
[212] Morowitz, p. 48.
[213] Christian Norberg Shulz, 1980, *Genius Loci: Towards a Phenomenology of Architecture*, London: Academy Editions.
[214] Norberg Shulz, p. 5.

Fig. 3.34. Norberg-Shultz's places of spiritual experience: Decumanus at Gerasa. Source: Christian Norberg Shulz, 1980, *Genius Loci: Towards a Phenomenology of Architecture*, London: Academy Editions, p. 72.

Norberg Shultz's thesis is that architectural objects are the sources of information exchange for the reason of their being always open to human experience. The cultural patterning of information exchange sets up the place identity of the region. The spirituality develops through the course of time when the flows of information attain a particular order. Norberg-Shulz's ideas regarding the significance of architecture as the possessor of cultural information are in a way in parallel with Galiano's. Norberg-Shulz developed his ideas on existential phenomenology by referring to the German philosopher Martin Heidegger, who argued in his famous text entitled "Building, Dwelling, Thinking" that to grasp the experience of dwelling was the genuine means of reconsidering man's existential roots. Norberg Shulz writes:

> First of all I owe to Heidegger the concept of *dwelling*. "Existential foothold" and "dwelling" are synonyms, and "dwelling" in its existential sense, is the purpose of architecture. Man dwells when he can orient himself within and identifies himself with an environment, or, in short, when he experiences the environment as meaningful. Dwelling therefore implies something more than "shelter". It implies that the spaces where life occurs are *places*, in the true sense of the word. A place is a space which has a distinct character. Sine ancient times the *genius loci*, or "spirit of place", has been recognized as the concrete reality man has to

face and come to terms with in his daily life. Architecture means to visualize the *genius loci*, and the task of the architect is to cerate meaningful places, whereby he helps man to dwell. [215]

Papanek's fifth principle supports the idea that a particular architecture can be considered as vernacular when it reflects the cultural flows that are generated out of the experience of a locality. Likewise, Norberg Shultz, in his book, gave place to vernacular artifacts for their being a base of knowledge on the local characteristics of a particular region. Consequently, Papanek's sixth and the last principle again divert us from interrogating the place of vernacular in the socio-cultural context, and render us to focus on the individuality of the artifact instead. The last principle puts that a particular artifact can be vernacular if only it has a cultural significance. An artifact can be considered as a cultural entity if its visual attributes are approved aesthetically. It is suggested that the aesthetic appreciation and individualism are closely linked; therefore, a product can be part of a particular culture if only it stems out of a designer's individual taste. However, Papanek censures this idea; he points out that vernacular indicates something collective; therefore, we should not seek for an individual response. He writes the following:

> Through several centuries one view of architectural ideology has been heard more loudly than others. It is the concept of 'artistic individualism', which finds particular buildings important, or evaluates general progress in architecture in architecture on a personal basis – usually of style, fashion, fad, decoration, embellishment or ornamentation embodied in specific buildings and developed from architect to architect through history. This traditional theory considers a building significant or unimportant according to how much it incorporates the 'idea of ideas' of its individual designer. The history of architecture then is seen as the interaction of such significant ides, developed in special buildings.
>
> This concept of architecture has only recently shown signs of losing its preeminence… The aesthetic explanation is too idiosyncratic and self-serving to interpret vernacular from on its own. We must observe ornament and decoration within the context of symbolic meaning. Too often the study of vernacular building is used by the critical establishment to lend historic credibility to some current architectural fad or fashion. [216]

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[215] Norberg Shulz, p. 5.
[216] Papanek, 1995, p. 134.

It is outlined in the previous chapter that the duality between communalism and individualism are also inherent in the discourse on the basic scheme of social interaction in the ecological sciences. We have seen that cooperation is brought forward in the equilibrium perspective of the systems sciences, while individualism belongs to the disequilibrium bias, which comes forward after the doctrines of evolutionary ecology re-entered into the systems arena. Furthermore, it was explained that in the new systems theory, individualism attains significance after it was understood that any single entity may determine the conditions of living. However, it was assumed that too much reliance on individual endeavor may disturb the balance of the existing life conditions, developed out of collective response. This disturbance may also affect human systems, alongside the existing ecological systems. It was argued that the new systems theory tried to overcome this duality by endowing the both/and position: that both collective acts and individual endeavors are important in keeping up biodiversity in the environment, if only social interaction is maintained. However, as mentioned earlier, the new systems scientists did not forget to remind us that it is communalism, which is the chief factor in keeping up biodiversity of the environment. Ecological systems keep their system stable by behaving, as the philosopher Capra's words, "in the wider context of cooperation."

David Pepper informs us that the confrontation between individualism and communalism also exists in the environmentalist discourse as well. He points out that individualism comes forward on the discussions about the role of an individual in creating a social change in favor of environmental appropriateness:

> …this implication of the personal lifestyle reform approach is usually submerged in notions of the individual self having a pivotal role in social change. Such individualism mistrusts mass revolution, arguing that it usually involves violence and oppression, the very ills that revolution intended to conquer in the first place… Individualism places faith, instead, in a continuous process of individuals changing their values and lifestyles, which should then produce a new society overall. This concept rests on an essentially liberal view of society, as the aggregate of the individuals in it.[217]

[217] David Pepper, 1996, *Modern Environmentalism,* London and New York: Routledge, p.115.

However, Pepper puts that the emphasis put on individual in environmental discourse is banned by radical environmentalists, because they claim that individual endeavor is not sufficient for the balance of our own environment; thus, collective action is needed. The censuring of individualism especially comes from the Deep Ecology branch, which is based on the Norwegian philosopher Arne Naess's holistic ideas that is found upon systems ecology and Asian metaphysics. Naess, in his 1973 paper entitled "The Shallow and the Deep, Long Range Ecology Movement; a Summary", that humans need to learn to live in conformance with the picture of an ecological environment, in which every organism is in cooperation and symbiosis for the well-being of our earth.[218] He believes that the prominence given to individual survival is the main reason for environmental destruction today. He assumes that for a long-time endurance on earth, man has to give up looking at 'life' "in an orthodox, individual-organism sense, and prefer to look at it through "a broad enough way to gather in such life collectivities, processes and contexts as species, ecosystems, and habitats".[219] Pepper summarizes the situation: "Given all this, ecological individualism is merely 'light' green: merely reflecting the individualism rife in mainstream society"[220]. As a result, the discourse on the vernacular introduces us to the two different means of dichotomies regarding the subject-matter. One of them is about the idea concerning the identification of a vernacular artifact, and the other one is the social pattern of behavior that the vernacular represents.

The vernacular means of construction is seen by the humanists as a means for the endowment of an ethical stance towards nature because of its being an emblem of communal action. Obviously, an ethical position does not develop unless those who contribute to the shaping of vernacular culture are not morally mature. This idea was put forward by the theoretician Paul Oliver.[221] He criticizes those who develop a one-

[218] Arne Naess, 1973, "The Shallow and the Deep, Long-range Ecology Movement: A Summary", *Inquiry*, vol.16, pp. 95-100.
[219] Peter Hay, 2002, in *Main Currents in Western Environmental Thought,* Bloomington and Indianapolis: Indiana University Press, p. 45.
[220] Pepper, 1996, p. 115.
[221] Paul Oliver, 2000, "Ethics and Vernacular Architecture", In Warwick Fox (ed.), *Ethics and the Built Environment,* London and New York: Routledge, pp. 115-127.

to-one correspondence between vernacular construction and ethical action. He mentions about the destruction brought forward through extensive housing construction in Africa. The houses are believed to reflect the vernacular spirit as they are developed by looking at the construction methods of tribal cultures. Oliver puts that the need of shelter, which is emerged because of the population explosion, obliged the inhabitants to build their own way in some regions of the continent. However, these activities attain a destructive character lately because of the increase in resource consumption. In this sense, there might be some cases in which the idea cannot be realized in practice.

3.2.2. Christopher Alexander's Systems Ideas on the Formal Synthesis

This section will give brief information on another equilibrium picture within the systems architecture, which was generated by the mathematician and the architect Christopher Alexander in the 70s. Like Fuller before him, Alexander's significance lies in his providing a coherency of systems position in architecture, while their contemporaneous followed the subject matter as a temporary social flow. Furthermore, like Fuller, Alexander utilized systems approach as a means to enhance architectural thinking. Both figures stressed the importance of developing a stable system of communication between social actors to build up lucrative places of living. Despite the aforementioned common patterns of thinking, their framework diverts in general. Their theoretical framework divert by means of their favoring of the technocratic and humanistic positions in the systems thinking.

Alexander writes in *the Notes on the Synthesis of Form* that he appreciates Fuller's systematization of architectural construction methods by geometrical patterning.[222] Despite that, he is critical to Fuller's way of approaching architecture. He writes in *the Pattern Language* that he disapproves Fuller's fostering of engineered

[222] Christopher Alexander, 1964, *Notes on the Synthesis of Form*, Cambridge and Massachusetts: Harvard University Press, p. 28.

development in architecture.[223] He finds vernacular forms more appropriate sample than engineered structures for architectural development. He believes that vernacular forms, rather than engineered structures, are the emblems of a steady-state cultural development as they took shape throughout the centuries of feedback response. Hence, Alexander, through his studies, endeavors to unite the space configuration methods of primeval cultures into a system of design knowledge. That condition brings him closer to the social activist figures who claim to return to past values through the use of vernacular revivals.

Hence, Fuller utilized systems approach to organize architectural construction, while in the case of Alexander it is mainly to develop architectural design knowledge. Fuller is concerned with the hardware, while Alexander deals with the software. Accordingly, as seen in the previous section, Fuller's pattern of thinking gradually steps down to the details from the top-down, being in congruence with his philosophy. However, it is painful to follow his successive mentality because the ideas are randomly distributed in his written documents. Unlike Fuller, Alexander's ideas are orderly arranged from the top-down to the bottom-up, being in parallel with the chronological order of his writings.

His first book, *Notes on the Synthesis of Form,* informs the reader about the ways of approaching architectural design as a system in which its sub-systems operates in a network of relations.[224] His other publication, *The Timeless Way of Building,* informs about the ways in which the design sub-systems are organized in the spaces of architecture.[225] Accordingly, *The Pattern Language* gives details about one of the design sub-systems, "patterns" as he calls them, which acts as an intermediary between form and context. He published a four-volume-work entitled *The Nature of Order* lately, in which he seems to return back from the details to the top-down

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[223] Christopher Alexander, 1977, *A Pattern Language.* New York: Oxford University Press, p. 942.
[224] Alexander, 1964.
[225] Christopher Alexander, 1979, *The Timeless Way of Building,* New York: Oxford University Press.

again.[226] Here, he guides the reader on the ways to approach the building system as a holistic entity that operates in accordance with the natural ecosystems in general.

In the *Notes on the Synthesis of Form*, which was published in 1970, the writer argues about the ways in which the design process is organized into a system.[227] He believes in the lack of a philosophical background to orient design towards the complexity of the current socio-cultural context. According to him, the design process is separated into particular design phases. The program development is the first phase of the design process. It is the process of organizing design problems that need to be solved. For instance, user needs and environmental considerations can be considered as design problems. Alexander emphasizes that the design problems can be organized in a set of connections when the designer is "able to find some sort of pattern in them".[228] Hence, patterns are the instruments of relations between formal configurations and contextual requirements. The second one is the formal organization phase. "The ultimate object of design is form", he notifies.[229] Lastly, the third one is the construction phase.

Alexander puts that the designer should pay attention mainly to the first phase of the design process, which is the program development phase, in order to give way to an appropriate formal configuration. Hence, the book gives clues about generating design program in a hierarchical order of problem subsets, which are to be configured under "patterns", to permit form and context congruity. He writes:

> … every design problem begins with an effort to achieve fitness between two entities: the form in question and its context… The form is the solution to the problem; the context defines the problem… The form is part of the world over which we have control, and which we decide to shape while leaving the rest of the world as it is. The context is that part of the

[226] Christopher Alexander, 2002, *The Nature of Order: The Phenomenon of Life*, The Center for Environmental Structure: Berkeley California.
[227] Alexander, 1964.
[228] Alexander, 1964, p. 15.
[229] Alexander, 1964, p. 15.

world which puts demands on this form; anything in the world that makes demands of the form is context. Fitness is a relation of mutual acceptability between these two.[230]

Alexander refers to analogies in his writings. He analogizes formal configuration with the biological set-up of a living entity, and the context with the entity's surrounding environment. The constituents of a living matter are bound in a network of relations that drives every member to operate efficiently in a certain environment for the maintenance of life. Similarly, the form has an internal set of connections that helps its constituents be in congruence with the context outside. However, form and context congruency is not likely to occur constantly; that, as Alexander puts, it is sometimes "subject to disturbances" in the cases of misfits.[231] Hence, the misfits make up of the design problems. Regarding the form and context incongruity, he exemplified about the misfit between a house and its users. Hence, the "patterns" are the means to trail off this misfit. A reminder can be given here that "disturbance" is a term belonging to the biological sciences. As designated in the second chapter, the term "disturbance" was introduced to the realm of biology after population ecologists informed about a disorderly picture in an ecological environment, rather than a stable one. It indicates "any event or series of events that disrupt ecosystem, community, or population structure and alters the physical environment."[232]

Alexander continues that the compatibility between form and context is commonly observed in the cultural products of the primeval populations, than those of the civilized ones. This is because primeval cultures undergo form making process by taking feedback response from their cultural setting, which acquired its stability for long periods of time. However, the cultural products of civilized societies take shape via the individual taste of the designer, which cannot be considered as a stable system for cultural approval. Accordingly, he prefers to identify civilized cultures as "self-conscious" for the reason that they develop their spaces with an awareness of architecture, art and engineering, and refers to the primeval ones as

[230] Alexander, 1964, pp. 18-19.
[231] Alexander, 1964, p. 27.
[232] The definition of disturbance is acquired from the following website: www.epa.gov/OCEPAterms/dterms.html

"unselfconscious" as they produce with a lack of such awareness. Hence, he summarizes his hypothesis within the following:

> Roughly speaking, I shall argue that the unselfconscious process has a structure that makes it homeostatic (self - organizing), and that it therefore consistently produces well-fitting forms, even in the face of change. And I shall argue that in a self-conscious culture the homeostatic structure of the process is broken down, so that the production of forms which fail to fit their contexts is not only possible, but likely. [233]

Alexander opens up his hypothesis by beginning with the unselfconscious cultures. He puts that the form-making process of the unselfconscious populations is conducted through the rigid control instruments such as "patterns of myth, tradition, and taboo which resist willful change".[234] The feedback control shortens the adaptation period of the formal arrangement to the cultural context. It renders the process to remain in a steady-state. The sub-systems of the design process can be modified independently and free of each other, while are being bound in a homeostatic relation. The sub-phases undergo self-organization with the aid of the trial and error of their makers in this equilibrium environment. Hence, Alexander's system of designing reflects the equilibrium picture of systems theory, which various disciplines, especially systems ecologists, abundantly benefited after its general contours were delineated by the biologist Bertalanffy. Alexander continues about how the design subsystems take "feedback" response from the cultural environment in order to remain in equilibrium:

> Let us now return to the question of adaptation. The basic principle of adaptation depends on the simple fact that the process towards equilibrium is irreversible…. The speed of adaptation depends essentially on whether the adaptation can take place in independent and restricted subsystems or not…. The direct response is the feedback of the process. The feedback must be controlled, or damped somehow. Such control is provided by the resistance to change the unselfconscious culture has built into its traditions… Each failure is corrected as soon as it occurs, and thereby restricts the change to one subsystem at a time… Rigid tradition and immediate action may seem contradictory. But it is the very contrast between these two

[233] Alexander, 1964, p. 38.
[234] Alexander, 1964, p. 48.

> which makes the process self-adjusting. …the process of adjustment is faster than the rate at which the culture changes; equilibrium is certain to be re-established wherever slight disturbances occur.[235]

Hence, Alexander analogizes the adaptation of architectural forms to the cultural context with the evolutionary adaptation of a living entity to its surrounding. His theorizing with the use of biological jargon, like "stability", "feedback", "homeostasis", "disturbance", etc., which belong to systems ecology in particular, is an indicator of his conformance to the socio-political currents of the 60s era, that displays an interest on environmental matters. As it was explained in the second chapter, it is the theory of cybernetics that drives the system theorists, including systems ecologists of this era. A thorough look at the reference notes of his book reveals that Alexander seems to get fully advantage of the cybernetic theory.

Alexander continues with the form making process of the self-conscious cultures. It is accomplished by the designer architect, rather than a craftsman. He informs that there is generally a misfit between form and context in the self-conscious type. The process is not controlled via a rigid cultural system oriented by customs and habits; therefore, it does not reach to equilibrium. The cultural products do not complete their adaptation to a stable system, because the system is itself subject to instant change due to modern patterns of living. Therefore, the creator architect develops an ordered setting himself/herself, which he/she can recourse to for approval. Alexander writes:

> To help himself overcome the difficulties of complexity, the designer tries to organize his problem… What bothers him is not only the difficulty of the problem either. The constant burden of decision which he comes across, once freed from tradition, is a tiring one. So he avoids it where he can by using rules (or general principles), which he formulates in terms of his invented concepts. These principles are at the root of all so-called "theories" of architectural design.[236]

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[235] Alexander, 1964, pp. 51-52.
[236] Alexander, 1964, p. 62.

Alexander emphasizes that the designer's individualism takes control of all the design process, as there is not a stable cultural development of approval. "The form-maker's assertion of his individuality is an important feature of his self-consciousness" he writes.[237] Indeed, as he puts, architecture became a discipline when the "old process of making form was adulterated" and architect's personality came forward in the cultural progress.[238] However, in the unselfconscious cultures, the form is not the end product of an individual's artistic expression, but of a larger set of homeostatic relations. As a result, as Alexander informs us, the form and context incongruity is generally observed in the self-conscious type. "To achieve in a few hours at the drawing board what once took centuries of adaptation and development, to invent a form suddenly which clearly fits its context- the extent of the invention necessary is beyond the average designer", he writes.[239]

In this sense, Alexander emphasizes that the program development phase becomes crucial in a rapidly changing environment in which the modern conditions of living are determinant. As mentioned earlier, he identifies the program development phase as the organization of contextual requirements in a hierarchical order of problem subsets, which he coins as "patterns" in particular. These patterns are related with each other, yet act independently at the same time. They project the cultural patterns a particular society, which develop by sharing of knowledge. As a reminder, Alexander claims that while the communicative bond is rigid in an unselfconscious society, it is flexible in modern cultures, which is the cause of the development of unstable architectural practices. The systematization of patterns is important as they bear the task of controlling the design processes. They are the mediators between form and context.

Hence, Alexander abundantly refers to mathematics to give the reader clues about how to systematize these "patterns". His example is the "kettle" as an object of production. He guides the reader to organize such user requirements as "fast

[237] Alexander, 1964, p. 57.
[238] Alexander, 1964, p. 58.
[239] Alexander, 1964, p. 59.

heating", "low thermal capacity", "hot water maintenance" under subsets that are bound in a problem network, yet are independent from each other. Indeed, his selection of the "kettle" as a particular example, which is a thermostatic arrangement, is a clear demonstration of his bias towards cybernetics, which is one of the canons of the systems thinking. He emphasizes that each separate problem definition should correspond to a particular solution in terms of formal arrangement. The problem subset can be modified in case there is feedback response from the user. Alexander represents problem subsets by using a diagram of trees, which was a popular means of presenting a certain arrangement by those who favor systems approach (Fig. 3.35). Furthermore, he mentions that a designer should represent problem subsets by drawing symbolic diagrams. He puts that these diagrams would prepare the designer for the subsequent form making process. He conceives them as a "bridge between requirements and form"[240] (Fig. 3.36).

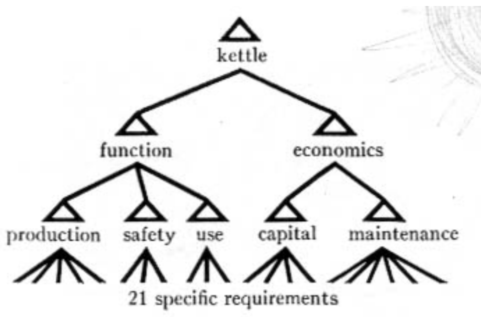

Fig. 3.35. Alexander's depiction of problem subsets in a tree-like arrangement.
Source: Alexander, Christopher. 1964. *Notes on the Synthesis of Form*. Cambridge and Massachusetts: Harvard University Press p. 62.

[240] Alexander, 1964, p. 92.

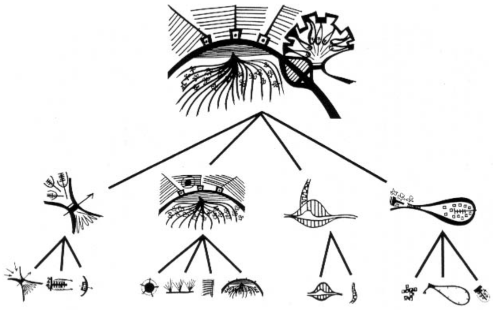

Fig. 3.36. Alexander's symbolic diagrams representing problem subsets.
Source: Alexander, Christopher. 1964. *Notes on the Synthesis of Form.* Cambridge and Massachusetts: Harvard University Press p. 62.

Alexander continues his notes on design in his subsequent book entitled *The Timeless Way of Building*.[241] Here, he is involved with the place of "patterns" in the design system and their general characteristics. He believes that the patterns stem from the language generated by a particular culture. Each culture determines what they deserve from their environment by sharing of knowledge. The degree of the cultural communication determines the degree of the stability of patterns. When there are close bonds in a society, the patterns lead to a homeostatic formal arrangement. When there is a lack of communication between actors, the patterns cannot be structured sufficiently; therefore the subsequent formal arrangement remains in disequilibrium. Alexander points out that the patterns of contemporary societies perturb architectural development as they do not give way to appropriate formal configuration. He puts that the patterns cannot be explained in the rationalist framework as they stem from communicative impulse.

According to him, the patterns resemble the genetic code of a living system. The codes are identical with each other in general structure, while are diverse in internal configuration. The diversity is the reason for the uniqueness of every living entity. The stability in the architectural design processes is bound to the stability of these patterns. The pattern can be reiterated in a different architectural process with slight

[241] Alexander, 1979.

modifications. These modifications are the reason for the adaptation of a built from to its context.

As mentioned in the earlier paragraphs, Alexander puts that problem development process is made up of sub-processes. According to him, the language structuring of patterns is the first phase of the problem development process. Then the designer represents these patterns in diagrams. The combination of these diagrams in terms of three dimensional arrangements make up of the building itself. "A pattern language is a system which allows its users to create an infinite variety of those three dimensional combinations of patterns which we call buildings, gardens, towns", he writes.[242] Just like a sentence is the combination of words, a building is the combination of pattern languages. (fig. pg. 187) The words are combined in a system of rules generated as the result of social communication, so do pattern languages. Therefore, the building process is not solely determined by the architect himself/herself. In the book *Notes on the Synthesis of Form,* he emphasizes that traditional societies realize their buildings via the pattern languages that became stable for centuries of feedback approval, rather than architectural drawings. He suggests developing our own stable design system with a reference to these pattern languages for a long-lasting architectural culture. In the book *Timeless Way of Building,* he puts that it is possible to create a universal system of design knowledge by organizing pattern languages. "The patterns, which repeat themselves, come simply from the fact that all the people have a common language, and that each one of them uses this common language when he makes a thing", he writes.[243]

In the *Timeless way of Building,* Alexander points out that industrialization loosened the tight social bonds, thus, disrupted the stability of pattern languages that lasted for centuries. Furthermore, that condition perturbed the feedback processes of formal configuration as well. The unselfconscious cultures undergo pattern development by looking at the growth models of living forms. However, the uneven pattern development of current societies unbounded the genetic connection of patterns with

[242] Alexander, 1979, p. 186.
[243] Alexander, 1979, p. 209.

nature. He emphasizes that we should regain this lost connection by rendering the pattern structuring to be a part of our cultural information flow. Then he mentions about how a particular pattern can be located in a system of communication. He puts that first of all there should be an abundant level of agreement within the community about the pattern. Therefore, its efficiency should be tested for a certain period of time. It is when the pattern gains “equilibrium with the forces which exists” and free itself from “mental interference”.[244]

Consequently, he believes that patterns diverse in scale, in parallel with the scale of the built form. The small-scaled patterns are the members of the large-scaled system of forces. The pattern of a particular building is the member of the one of a city. Each pattern is connected with each other in a network. They form a design language system when they come together. “The genetic character of species is defined by its gene pool”, he writes, “Just so, a common language is defined by a pool of patterns.”[245] These patterns enter into the path of evolution as people exchange ideas about the environment. The patterns, which evolve in the network of communication is the reason for a built form’s “wholeness”. Indeed, as Alexander puts, the language of communication is only an instrument, but not the assurance of a holistic architecture. It is when the designer frees himself of his ego and conceives his patterns as a social act, rather than an individual means of expressionism.

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[244] Alexander, 1979, p. 304.
[245] Alexander, 1979, p. 343.

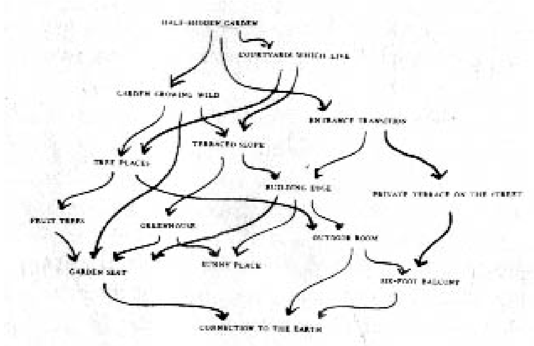

Fig. 3.37. Alexander's pattern fields of interactions.
Source: Christopher Alexander, 1979, *The Timeless Way of Building,* New York: Oxford University Press, p. 314.

Alexander concludes to interrogate the place of "patterns" in the general system of design and shifts to the pattern making process in his subsequent book, *The Pattern Language*.[246] He guides the reader about what these patterns are, how they are generated and how they make up a town or a building system when come together. He mentioned in his earlier book that the combination of the pattern diagrams in terms of three dimensional arrangements make up of the design of the building. Hence, he descends from the top-down outlook to the details of the form making process. The systems terminology is not existent in his writings anymore; however, he still seems to be benefited from the holistic philosophy. Basically, the book is arranged into the system of scales. Alexander believes that each pattern is related with each other in a network of relations; the small-scaled one is the member of the larger one. Therefore, he begins with explaining the patterns of a town fabric, and then slowly descends into ones of a building.

The first part of the book is about how the patterns such as "city country fingers", "subculture boundary", or "local town hall" make up of the town structure. While pointing out how they come together in a town, he gives us clues on how to reduce the ecological burden of towns on our planet at the same time, such as, enhancing the social communication between the inhabitants, increasing the green regions,

[246] Alexander, 1977.

decentralization to reduce urban sprawl, supporting urban transportation to reduce congestion etc. He believes that the continuous sharing of knowledge between the members of the society is the way towards the ecological development of towns. A town which stem from a communicative impulse, rather from any individual's planning act is the way towards livable towns and livable environment.

Then he turns to the patterns of the building, such as, "roof layout", "communal eating" or "gallery surround", and exemplifies how they come together in an architectural form. He believes that like those of towns, the buildings which enhance social communication, like cluster structures, low density forms, building thoroughfares that act as shortcuts between neighbors etc., is the way leading to ecological means of education. Furthermore, not only social communication, but also, proper siting and orientation, construction of greenhouses and green terraces are some of the ways leading towards a more environmentally-sound built forms. He censures the seeking for individual expressionism in the form making processes.

Hence, he reiterates this idea in his later book in four volumes, namely *the Nature of Order*.[247] He points out that the livable buildings are the ones which stem from the shared cultural patterns of societies, rather than an individual taste. The building structure should be considered as the abiotic member of ecosystems. Therefore, not only living systems, but also building systems make up of the phenomena of life. The creativity of human societies, as well as the creativity of nature is also a part of our world ecosystem. The exchange of knowledge is significant in the enhancing of livable environment. He believes that the sharing of subjective experiences resembles the exchange of abiotic matter between organisms in an ecosystem. He puts that this idea is in a way contradictory to the conventional biology, which dwells on evolutionary perspective and ignores systems ecological approach. Evolutionary ecology focuses solely the relations of living populations, rather than those between biotic and abiotic matter. The buildings that reflect the spiritual impulses developed out of cultural currents contribute to the enhancement of biological life.

[247] Alexander, 2002.

As a result, the influence of systems thinking was obvious in the first book, *the Notes on the Synthesis of Form.* The book seems to be written by following the interest in architecture to the systems thinking in those years. Indeed, it may be for that reason that a coherent outlook is more observable in his first book than his other works. Furthermore, his concern of systems science seems to bring forward a concern for environmental matters as well. In *The Timeless Way of Building*, it is possible to observe the disappearance of the cybernetic language in favor of the semiotic one. However, the holistic mentality is still valid. As the chronological order of his writings suggest, his interest to the environmental subject-matter ascends in the course of time. The increased rate of deterioration might be the reason for his growing interest.

Alexander's ideas were influential on those who strive to develop a counter practice against the abundant use of technological issues by reviving the vernacular means of production. Furthermore, his works paved way to those who try to rationalize their design methods in order to develop their practice which is on the side of social concerns. Hillier and Leaman's aforementioned article, which is about the systematization of design knowledge by searching the primeval methods of space planning for instance, widely echo Alexander in this respect. Their mathematization of space organization is because of the influence of Alexander, who uses mathematical formulas in the development of his ideas. Furthermore, as it will be seen in Chapter 5, Alexander's ideas make up not only the humanistic vision of those years, but also of the green architecture in the contemporary period.

Throughout the chapter, it was argued on the ways in which architects followed the social interest to the holistic outlook, which was inaugurated due to the ascendancy of environmental problems. Furthermore, it was outlined that the holistic outlook was appropriated to architecture in the 60s with regard to both technicist and social activist branches of thought. Accordingly, in this section, it was argued that vernacular architecture was utilized as a means to promote social interaction against the fact on alienation from communicative impulses due to the modern patterns of living. It was explained in the previous paragraphs that the discourse on the vernacular is in favor of the idea about an architectural form having a cultural significance when it is the product of communal activity. It was seen that Alexander set up his ideas to emphasize vernacular production as a cultural product of feedback response, which may help to set forth the values of the past that belongs to the periods when nature was valued with a non-exploitative attitude. Consequently, it will be seen in the subsequent chapter that while the 60s technicist branch provided a basis for today's green architects that favor technological progress against environmental issues, the social activist wing helped in the development of a wide spectrum of green practices ranging from regionalist revivals to self-built houses.

CHAPTER 4

A THOROUGH LOOK AT THE CONTEMPORARY TENDENCIES IN GREEN ARCHITECTURE

4.1. On the Technicist Bias towards Self-Sufficiency

As it has already been mentioned in the Third Chapter, systems approach was appropriated within the discipline of architecture with regard to the cybernetic theory –in parallel with its consideration in the ecological sciences. It was assumed as a critical frame of thinking to shape the future of human settlement on the planet. The philosophical background that the systems approach provided was supposed to be different from the ruling technicist and recessive social activist views. It was understood that the social activist branch projected their critical attitude by means of diverse practices, from vernacular revivals to garbage housing. Furthermore, it was put forward that these twofold approaches still existed in the applications of systems thinking, despite the demands to overwhelm them.

Indeed, as it was explained in the Second Chapter, both the appraisal of industrial rationality and the search for the lost connection with our primeval roots existed in the systems ecology as well, like they existed in architectural thought. As put by Worster, the historian of ecology, these binary oppositions were the heritage of the Enlightenment mentality.[1] He puts that systems ecology harbored these two different attitudes under its holistic umbrella in terms of a confusing mixture, because of the ambiguity in the scientific assumptions on planetary survival.

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[1] Donald Worster, 1995, *Nature's Economy: The History of Ecological Ideas,* Oxford: Oxford University Press, pp. 342-433.

Systems approach is still helpful for the architects who prefer to deal with the growing complexity of environmental problems today. In this chapter, it will be argued that environmentally-sound architectural practices are supplanted by a holistic mentality provided by the post-war systems ecology in particular. It will be claimed that the dominancy of technicist paradigms continue in today's green architecture like it existed in the architecture of the 60s. Moreover, it will be put forward that this technicist bias is encountered with reactions as it was encountered in the architecture of the 60s. After a brief outlook on the contemporary technicist agenda, the reactionary tendencies will be outlined.

4.1.1. Sim van der Ryn's Investigations on Environmental Control and Self-Sufficient Architecture

As it was mentioned in the Third Chapter, while the architects who shared the technicist view welcomed the terminology brought forward by the theory of open systems, the social activists introduced the information theory regarding systems science. The technicists envisioned their built works in which industrialized hardware and design software constituents are interconnected in a feedback scheme. The architectural system was considered with regard to its totality of technological configuration, rather than with regard to the wider context of social, cultural and environmental relations. The architects' preoccupation with the systems approach in the 60s was not for improving the environmentally-sound peculiarities of their built works; it was rather for developing the processes of the building design and construction in general. The mechanical implementation was for enhancing human comfort conditions, rather than caring for the natural environment.

However, that situation changed a decade later on the side of environmental well-being. The emergence of energy crisis due to the oil embargo in the 70s gave rise to the reconsideration of systems approach in architecture in order to investigate on the energy efficiency at the household level. The schools of architecture raised funds to the interdisciplinary projects in order to discover household technologies that operate with renewable energy sources, such as wind, sun and water. Research teams investigated on the self-sufficient dwellings that cycle energy with developed thermostatic systems; thus contributed to the development of environmentally-conscious architecture in this respect. Such projects as Autarkic House by the English architect Alexander Pike displayed how technological self-sufficiency could be achieved without any harm to the natural surrounding.[2] Autarkic House was part of an experimental research project pursued with the Cambridge University School of Architecture in the 70s. The house dwellers were assumed to utilize solar and wind power for the domestic maintenance. The solar collectors that covered the entire unit were in charge of heating the overall building and the water system. The wind generators that situated on the rooftop provided electrical power. The methane generated from the garbage products was used in the kitchen for cooking. The double skin glass wall of the north facade was both an insulating element and a conservatory for plants. However, the project was realized only as a model structure coupled alongside its computer simulation. Despite that fact, it gave way to later innovations about how to achieve environmentally-sound self-sufficiency (Fig.4.1).

Fig. 4.1. *Alexander Pike,* Autarkic House, *Cambridge, 1971/79.*
Source: Agnese Ghini, 2004, "Tecnologie per l'igiene edilizia e ambientale", http://distec.unipr.it/cgibin/campusnet/moduli.pl (accessed March 2006).

[2] The following information was compiled from John Farmer, *The Green Shift,* Oxford: Architectural Press, p. 197.

Such figure who pondered on the techniques of ecological dwelling a decade later was the American architect Sim van der Ryn. He compiled his investigations on environmentally-conscious houses in a book entitled *Integral Design*, published in 1978, the year which he served as the State Architect of California.[3] In the book, which was introduced by Buckminster Fuller as an "inspiring record of eco-technically effective intelligent human cooperation",[4] he puts his aim as the "integration of architecture with ecology".[5] Van der Ryn argues that the architectural productions should take part in the efficient energy exchange of the equilibrium ecosystems. According to him, the architects should be trained on the negentropic capacity of ecosystems before the designing of their buildings. Indeed, in the book, he informs about the equilibrium ecosystems for those who aim at steady-state design:

> Negative feedback loops are found in biochemical pathways of cellular metabolism and the population swings of ecosystems, in which the expansion of particular species is limited by predators, or where stresses related to crowding inhibit reproduction. Healthy steady-state recycling is maintained by the linkage of complementary systems so that the wastes of one system are the necessary inputs of the other.[6]

He continues that although it is unlikely for human systems to achieve the homeostatic capacity of natural ecosystems, humans should at least take precautions against further degradation. Indeed, today there is a fact about human dwelling practice being 50% responsible for deprivation. Therefore, it is obvious that the architects have to render their productions a contributor to the equilibrium environment. However, as he puts it, the homeostatic building practice, as it was entirely suggested in the systems approach, differs from the standard one. He points out that in the former one, the architectural object is considered as a link within

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[3] Sim van der Ryn, 1978, *The Integral Urban House: Self Reliant Living in the City,* Sierra Club Books in Charles Jencks, *Theories and Manifestoes of Contemporary Architecture.*
[4] Sim van der Ryn, 2005, "Sim's Books", http://www.vanderryn.com/va/methods-simsbooks.html, (accessed March 2006).
[5] Van der Ryn, 1978, p. 16.
[6] Van der Ryn, p. 20.

planetary energy cycles with its steady-state configuration; while in the latter case, it is a solitary structure in which energy flows without being subject to any feedback control. The standard architectural object is an open system in which energy flows through closed cycles; while the ecological one is a closed system in which energy follows a linear path. He believes that an architectural object should take part in the planetary energy currents without giving way to excess energy consumption. The more energy flows in a system, the less is its possibility of capturing equilibrium. It is because of such reasons that he believes in feedback control as significant issue for an open system. He writes:

> Too much energy flow is detrimental to ecological systems. An overload or surge of energy flowing through a system can be destructive to the information content that is embodied in its structure and form. This is true of natural as well as man-made systems. [7]

Van der Ryn puts forward a set of principles to conform architectural production to the cycles of nature. First of all, as he puts, architects should render every material component as a part of this feedback loop. He emphasizes that demountable and modular systems are sufficient in this respect. The demountable materials can be reused in another context even when the building completes its period. Modular systems curb the amount of energy consumed during the process of their production. Energy efficiency increases when the material components are designed for easy transportation and reconstruction. Secondly, he puts that the building should be designed by putting emphasis on the passive heating and cooling strategies. For instance, it should contain considerable amount of ducts to allow energy circulation inside the spaces. Thirdly, its spatial configuration should give way to multitude of activities, rather than a single purpose. Such a multipurpose building, which contains living and working spaces in a single volume, can curb the transportation costs of the dwellers for instance. The fourth one is enhancing the homeostatic activity of the building by proper waste and water management systems. That condition evades valuable energy loss. The fifth one is rendering the built form as a source of information in the larger context of cultural exchange. An environmentally-

[7] Van der Ryn, p. 21.

appropriate built form conserves important knowledge of ecological bookkeeping, which is to be transmitted to future generations.

As mentioned in the third chapter, the Spanish architectural theoretician Galiano put forward that morphological configuration is significant in ecological sciences as it is in architecture, because it is considered as a source of valuable information for steady-state development. Galiano gave place to the Spanish ecosystem ecologist Margalef in this respect, who writes the following in his book entitled *Perspectives in Ecological Theory*:

> Thus, conservatism seems to be a law of nature, and systems endowed with the highest stability of form -no new properties being added that are not accounted for- may be rightly considered the best channels of information.[8]

Hence, the internal configuration of a built entity, by conserving valuable information for a steady-state development, helps to maintain the equilibrium environment. Van der Ryn suggests architects to imitate the morphology found in nature in order to provide energy channels in a formal structure. His focus of attention was low rise housing structures, the morphological configuration of which contributes to the household ecology. He aims at setting forth the "integral" design systems as opposed to the "linear" ones of standard practice, which evade the biodiversity of nature. He writes:

> The task, then, of integral design at the household level is to begin to recreate the opportunities for people to derive meaning and satisfaction from their experience of natural cycles as these occur at the household. This assumes that the occupant becomes an active and intelligent participant in managing, maintaining, and adapting the dwelling.[9]

As a result, Van der Ryn assumed his living spaces to be the channels of both energy and information in a self-regulating environment. He was concerned on the

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[8] Ramon Margalef, 1968, *Perspectives in Ecological Theory,* Chicago and London: The University of Chicago Press, p. 3.
[9] Van der Ryn, p. 21.

environmentally-sound dwellings in the period in which there is a transformation of understanding from the concern of an architectural object as a mechanical system of human well-being, to an open system of environmental well-being. In 1978, Van der Ryn decided to shift his ecological view to a larger scale by means of his Gregory Bateson Building in Sacramento.[10] The building is composed of the cluster of office spaces that are gathered around an atrium at the center. Basically, it is considered ecologically appropriate at the institutional level because of its passive cooling and lighting systems. For instance, the air cooled at night in the atrium space is released to the office spaces during the day through the channels that act as thermal labyrinths. The rockbeds situated at the basement level of the atrium store cool air at night. The tall canvas tubes that contain fans hinder stratification of air inside the atrium and give way to its circulation in the entire building clusters. The vegetation at the courtyard also supports air conditioning. The cavities inside the floor slabs absorb excess heat. As Van der Ryn informs us, the passive heating and cooling systems reduce the dependency on fossil fuels at 70 percent. As the skylights that overlook the corridors provide indirect sunlight to the office spaces, the need for artificial lighting is reduced. The solar panels located at the rooftop generate electricity and thus curb the dependency on non-renewable energy resources (Fig.4.2).

Indeed, Gregory Bateson Building is rich in its ecological attributes, while being poor in its interpretation of natural forms, which is considered by Van der Ryn as important for the future survival. Accordingly, he attempts to compensate that loss through his later designs. For instance, the Real Goods Solar Living Center in Hopland, California displays Van der Ryn's efforts of attaining ecological self-sufficiency through its formal configuration, alongside its proper orientation, energy recycling systems and material selection. Situated on a "12-acre parcel", which was "once a dumping ground for highway rubble", the building is designed as a showroom for the ecologically sustainable household products of the Real Goods

[10] The information is compiled from the following: Sim van der Ryn, 2004, "Gregory Bateson Building", http://www.vanderryn.com/va/index-projects.html, (accessed Marc 2006).

Trading Company.[11] Like the ones of his Sacramento building, the spaces of the Real Goods Center are clustered around an open area in order to enhance passive cooling. The fountain at the center support the passive ventilation attributes by cooling the air that is abundantly heated especially during summer. Proper siting and orientation reduces the need for artificial lighting. Shading devices control the light penetration during summer season and avoid excess heat. The vegetation enhances the impact of fountain at the center. Ecological equilibrium was sought not only within the building itself, but also in the extensive land in which the building is situated. Solar powered devices pump the recycled water inside the building to cool the spaces, and outside area to irrigate the land. The building hardware is arranged out of non-toxic and recycled materials, such as straw bale and non-chemically processed timber. The stepped roof, which shades the windows, is made with the recycled automobile tires and redwood. The insulation material is straw bale covered with "pneumatically applied earth and cement mixture".[12] The photovoltaic panels and wind generators that are situated at the nearby generate energy when needed. They have the power to supply energy to the entire area as well as the local energy company. Furthermore, Van der Ryn considers his building a source of information in the larger context of cultural exchange; that its formal disposition displays the features of his principle regarding the conformance of nature. The buildings are clustered in a shell-like disposition. The curved roof structures are recessed sequentially resulting a seashell formed site development that becomes explicit when looked at the top. The landscaping at the center also conforms to the seashell-like site with the pond ending at the center (Fig. 4.3).

[11] Sim van der Ryn, 2004, "Real Goods Solar Living Center", http://www.vanderryn.com/va/index-projects.html, (accessed March 2006).
[12] James Wines, 2000, *Green Architecture,* Philip Jodidio (Ed.), Köln: Taschen, p. 122.

Fig. 4.2. *Sim van der Ryn,* Gregory Bateson Building, *1978.*
Source: Sim van der Ryn, 2004, “Gregory Bateson Building”,
http://www.vanderryn.com/va/index-projects.html, (accessed March 2006).

Fig. 4.3. *Sim van der Ryn,* Real Goods Solar Living Center, *Hopland, California, 1996.*
Source: Sim van der Ryn, 2004, “Real Goods Solar Living Center”,
http://www.vanderryn.com/va/index-projects.html, (accessed Marc 2006).

Van der Ryn’s ecological approach to architecture has manifold dimensions. He is concerned with the environmentally-sound architecture not only at the individual building level, but at the suburban level as well. However, his strategies change when it comes to the community development in suburban areas. In the book that he co-authored with Peter Calthorpe, he claims that the architecture for the community does not need to be self-sufficient, although it aims at a steady-state development.[13] Sustainable communities, rather being autonomous entities that operate with regard to their integral feedback arrangement, should be sub-systems within the wider physical and cultural set of relations. Therefore, contextual peculiarities, rather than technological hardware gain significance in housing at the suburban scale. Architects should be concerned with the regional values of a certain locality beforehand focusing on technological paradigms. Indeed, the writers believe that too much reliance on technology impedes negentropic land use patterns in a sustainable community. One should avoid any form of development that increases the dependence on industrial mass production. For instance, car-oriented circulation patterns cause the abundant emission of wasteful energy to the environment. Therefore, pedestrian walkways, rather than roads should dominate the design of suburban housing for the well-being of both the natural and the human ecosystem.

Furthermore, the writers argue that social patterns of development should be the fundamental concern for setting up the contextual bond in a particular locality. Therefore, in a sustainable community, the built matter should be designed in such a way that it should enhance neighborhood development. For instance, building in clusters is one of the strategies that bring people closer to one another, thus closer to nature as well. Clustered spaces bring forward compactness, as well as social interaction. In this sense, cluster development seems to be the only criteria that Van der Ryn seems to sustain as a principle in a building scale, as well as urban scale. The writers argue that the fundamental principle that brings forth social network of relations is the design for "diversity"; be it social, cultural or economical.

According to the writers, the first form of diversity is concerned with the building functions. Here, the built forms must contain spaces that meet not only a single purpose, but a multitude of activities. As mentioned earlier, mixed-use buildings, as they contain diverse functions in a single volume, also reduce transportation costs.

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[13] Sim van der Ryn and Peter Calthorpe, 1991, *Sustainable Communities,* 2nd edition, San Francisco: Sierra Club Books.

The second type is the social diversity. Accordingly, the dwellings should not project the needs for a particular social class; rather they should be designed for the people with diverse patterns of living. As mentioned in the second chapter, ecosystem scientists put that equilibrium is possible in a community in which diverse species interact in manifold ways. Correspondent of the ecological system, the diversity of interactions is considered as one of the ways to capture ecological stability in human social system. The third one is the diversity of circulation patterns. The trajectories in a neighborhood development should not be composed solely of those for the vehicle flow, but for bicycle and pedestrian movement as well. Therefore, roads with various sizes, such as paths, walkways, side roads, intermediary roads, alleys should govern the design. The fifth one is the diversity of transportation. The housing infrastructure should not only be based on the relocation of individuals, but also of the public.

The sixth type is the diversity of densities. Obviously, a neighborhood development is dominated by low-rise dwellings. However, homogeneity in densities is not a preferred principle in a suburban area. A sustainable place is the one in which contains built forms at different levels of development. The last principle is the diversity of economic forces. The economy of a suburban area should not be based solely on the development of global capital, but also of the local enterprises. Regional endeavors are one of the means that contribute to the enhancement of the network of social relations.

Van der Ryn’s ideas about the ecological equilibrium at the community level have certain parallels with the ones provided by the post-war ecologists regarding natural ecosystems. As mentioned in the second chapter, in the post-war era, cooperation is the subject-matter of ecosystem ecologists as well. The ecosystem ecologist Eugene Odum brought forward the communitarian means of metabolic functioning in ecosystems as a way towards negentropic development. In this picture, metabolism is the process of maintaining internal order for survival. Odum followed his sociologist father Howard Odum in this respect, which considers regionalism as a strategy of cooperation and coordination among the nation's major areas, delimited by geography, history, and culture. Hence, Howard’s emphasis given to regionalist values found a place in the environmentalist ideologies a decade later, in studying the communal patterns of individuals in a social setting for an environmentally benign future.

Van der Ryn refers to the technicist paradigms of the systems approach when he deals with the individual dwellings. Technological self-sufficiency is his primary concern when he does not suppose his buildings to interact with the larger network of relations. However, the technicist paradigms are replaced with the communitarian ones when he locates his dwellings in a suburban context. The social patterns of communication become his primary concern. Indeed, like Van der Ryn, some architects refer to other perspectives aside from the dominant technicist paradigm in their works. Van der Ryn prefers to get help from the technological tools, while setting forth communitarian relations in his green designs.

4.1.2. Thomas Herzog's Solar Innovation

Indeed, the amalgamation of technicist paradigms with the other perspectives was not generally the case in the systems architecture of the 60s, as it is today. As put forward in the second chapter, those who set forth their systems understanding in those years prefer to be involved with either the technological advancement or with the enhancement of social relations. Despite the appropriation of a coherent outlook, however, occasionally some of them integrated other viewpoints within their discourse.

Van der Ryn prefers to give place to communitarian values alongside the technicist paradigms in his architecture, which he philosophically supports from the systems approach. However, some architects are still more coherent in their appropriation of systems approach. Such figure is Thomas Herzog, the German architect, who began practicing with an ecological awareness at the end of 70s. His primary concern is the utilization of renewable energies in his architecture. As he prefers especially to make the most of solar power, technological research and innovation plays a major role in his built works. Although he did not develop a comprehensive argument to support his ecological practice, he refers to terminologies put forward by the technicist branch of the 60s architecture.

For instance, in the book that he edited in 1996, Herzog emphasizes that the holistic approach should be the major issue in contemporary architectural practice.[14] He puts that the energy consumption in the building should be counterbalanced by the inputs generated by the renewable sources. Indeed, the book was mainly about the methods of energy calculation, computerized management, controlling of outputs and outputs, being the strategies to keep the building in a steady-state. He mentions about the work of the physicist Wolfgang Palz who deals with the energy calculation methods that could be used in the avoidance of entropic degradation in the buildings. Moreover, Herzog suggests architects to rely on the newly manufactured systems that render material hardware more durable and energy efficient. He recommends using innovative sunscreens that provide shading with their filtering systems. He points out that he endows a more pragmatic approach to render his architecture ecologically efficient. Yet, he puts that architectural expression should not be ignored while searching for ecological efficiency. His architectural expression is not based on formal experimentation; his approach diverts from that of Van der Ryn in this respect. He is innovative in his ideas on the implementation of the passive energy systems to his built works.

His 1977 house in Regensburg is his earliest achievement on the negentropic building systems.[15] It is designed as a triangular glass prism. Its double skin façade captures sunlight. The light is distributed throughout the spaces with the help of a wide sloping surface of the south direction. Herzog finds diverse ways to render his solar devices be a part of his architecture. In the Regensburg case, the sloping feature of the façade is what makes the building significant (Fig. 4.4.). Accordingly, he

[14] Thomas Herzog (ed.), 1998, *Solar Energy in Architecture and Urban Planning,* 2nd edition, Munich: Prestel.
[15] For the details of Herzog's Regensburg house, see James Wines, 2000, *Green Architecture,* Philip Jodidio (Ed.), Köln: Taschen, pp. 132-136.

continued using the outer surfaces as instruments for passive heat gains in his later practices. For instance, in this Exhibition Complex located in the city of Linz, the captivity of light is achieved via the roof (Fig. 4.5).

Fig. 4.4. *Thomas Herzog,* House in Regensburg, *Germany, 1977-1979.*
Source: Thomas Herzog, 2003, "House in Regensburg", http://www.herzog-und-partner.de/english/html/projects_-_house_regensburg.html, (accessed Mar 2006).

Fig. 4.5. *Thomas Herzog,* Congress and Exhibition Hall, *Linz, Austria, 1986-1994.*
Source: Thomas Herzog, (ed.), 1998, *Solar Energy in Architecture and Urban Planning.* 2nd edition. Munich: Prestel, p. 145.

His house in Waldmohr is also significant in its passive heating technique.[16] Here, the design strategy for the light captivity finds its spatial configuration; rather than the façade arrangement. He located spaces, which require more heat, to the center of the building. He surrounded these spaces with the ones that need less heat, so that they situate near to the façade. Furthermore, on the south axis, he made two separate glass facades to create a thermal buffer zone. Between the facades he located a conservatory that produces hot water to heat the floors (Fig. 4.6.).

Herzog benefited from the technological devices in his 1991 Hostel for Youth in Windberg.[17] Here, again the planar surfaces were the generating elements of his ecological design strategy. They were designed in a modular structure in order to carry the passive heating systems. Heat pipe collectors were installed at the south facing roof. The translucent insulation panels were erected in order to broaden the daylight use. Mechanical ventilation systems are planted at the top level in order to recover the loss of heat during the day (Fig. 4.7).

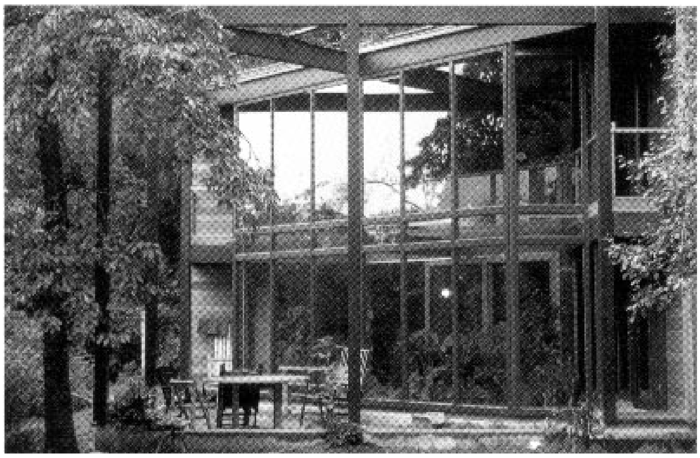

Fig. 4.6. *Thomas Herzog,* House in Waldmohr, *Germany, 1982-1984.*

Source: James Wines, 2000, *Green Architecture,* Philip Jodidio (Ed.), Köln: Taschen, p. 136.

[16] For the details of Herzog's Waldmohr house, see James Wines, 2000, *Green Architecture,* Philip Jodidio (Ed.), Köln: Taschen, pp. 132-136.

[17] For the details of Herzog's Hostel for Youth, see Thomas Herzog, (ed.), 1998, *Solar Energy in Architecture and Urban Planning.* 2nd edition. Munich: Prestel, p. 66.

Fig. 4.7. *Thomas Herzog,* Guest Building for the Youth Educational Centre in Windberg, *Germany, 1987-1991.*
Source: Thomas Herzog, (ed.), 1998, *Solar Energy in Architecture and Urban Planning.* 2nd edition. Munich: Prestel, p. 145.

Thomas Herzog's architecture is based upon achieving ecological self-sufficiency through the application of technology. In his housing projects, he is more focused on enhancing passive technologies, rather than social means of communication. An example may be his 1995 Solar City in Linz. Here, although neighborhood development is not ignored as a design strategy, the importance is given to the solar gain systems of the dwellings themselves (Fig. 4.8). As a result, Herzog's architecture is one of the examples of the technicist development within the contemporary architecture. A comprehensive discourse hardly appears in his writings; but the remnants of the systems approach can be observed in his practice.

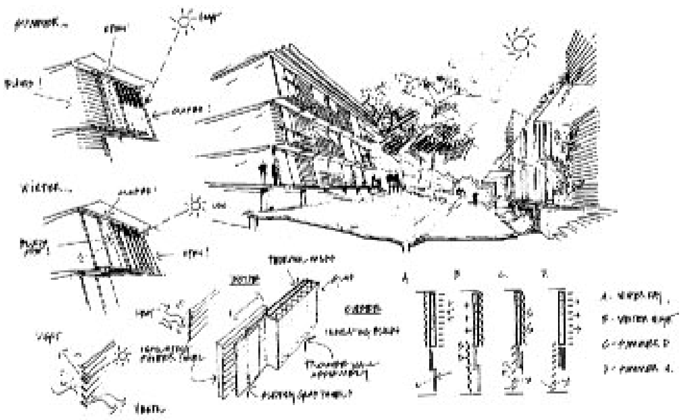

Fig. 4.8. *Thomas Herzog,* Solar City in Linz*, Austria, 1995. Skeches.*
Source: Miguel Ruano, 1999, *Ecourbanism: Sustainable Human Settlements,* Barcelona: Editorial Gustavo Gili, p. 62.

4.1.3. Geodesic Living Machines of the Todd Couple

The reconsideration of systems approach in architecture after the 70s went in parallel with the energy crisis of that period. Self-sufficiency became the jargon and architects worked on enhancing the thermostatic qualities of their buildings. The studies on the efficient technologies of the household ecology gave rise to the development of environmentally-conscious architectural works of diverse scales. Hence, due to the social conjuncture of the era, architects were more pragmatic in their rendering buildings self-regulating machines. Despite that, some still approached the subject matter from its moral side rather than the pragmatic one. They utilized architecture as a means to prevent ecological damage rather than energy consumption. Systems thinking helped them in the development of technologically mature architectural systems that help to regain the regenerative peculiarity of the planet earth.

Such example was John Todd, the marine biologist who is famous for his geodesic sheltered technologies that heal the contaminated areas.[18] Todd began his studies with his wife Nancy in their New Alchemy Institute that they established in 1969. The couple developed domed-over greenhouses -"bioshelters" as they call them- to experiment on the supporting ecosystems of human habitats. Each bioshelter contained ecosystems of diverse scale. With the aid of science and technology, these ecosystems rendered household economy environmentally appropriate.

Accordingly, in the 1980s, they improved the technology inside their bioshelters in order to treat larger contaminations. The bioshelters became, as they called, the "living machines" and rendered the deteriorated watery areas environmentally benign. Each living machine contained natural ecosystems, which were developed out of member species that have the peculiarity of processing waste. The biotic and abiotic members of ecosystems changed in every living machine due to the degree and characteristic of wasted area contained inside the structure.

Todds are still involved with purifying aquatic lands in the Ocean Arks International, which is a private foundation that they established for that purpose. Like bioshelters, living machines are also generated out of geodesic structures. Its material systems take shape out of industrial manufacturing. The energy generated via the geodesic dome materials, which were the solar capturing devices themselves, drive passive energy systems and supply energy for the contained ecosystems. The watery surface inside the living machines is treated by undergoing natural processes, rather than chemical ones. The natural means of purification take place with the help of ecosystems that undergo nutrition and respiration through the supplied energy which is captured inside the glass of geodesics. Recently, they work on the ways to utilize the purified water inside the living machines for city farming. In this process, the water becomes an ecosystem itself containing members which are suitable for human

[18] The details of the couple's working methods can be obtained at: Robert Gilman, 1990, "An Interview with John and Nancy Jack Todd", http://www.context.org/ICLIB/IC25/Todd.htm, (accessed June 2006).

nutritional needs, such as vegetables, fish and plants etc. Nancy Todd explains about their healing and food production methods in the following:

> A Living Machine is a contained ecosystem which is designed to accomplish a specific task or series of tasks. In the case of food waste treatment, waste water is guided through a series of cylinders - each one with a different ecosystem, each with a different combination of microbes, plants, and animals. As the water passes through the various systems, different contaminants from bacterial to heavy metals to industrial waste are removed. As you move along in the process, toward the mid-section of the tank, you begin to introduce higher plants, snails, and fish.[19]

Todds published a book in 1984 entitled *Bioshelters, Ocean Arks and City Farming*.[20] They clearly state in the book that their "bioshelters" are based on Fuller geodesics. Indeed, Fuller's influence for them is not solely about his architectural solutions that helped in the re-integration of natural processes to the watery areas. They pointed out that they undergo their treatment processes with the aid of a coherent outlook provided by Fuller. They emphasize that Fuller taught them how to approach nature as a regenerative closed system going against the "arrow of time", owing to outside energy sources, which is, sun radiation and moon gravity. Hence, their bioshelter units operate in a way similar to the bioregenerative system of our planet earth. The ecosystems inside are enclosed in a closed spaceship that follows the geodesic feedback route.

Accordingly, the Todd couple mentioned about another figure that shaped their approach to ecological design in their book. It is the systems scientist James Lovelock, who set forth the idea that the earth is itself a living system keeping the world ecosystems in an equilibrium state. Likewise, their geodesic shelters envelop the ecosystem components to stay in a steady-state. They put that geodesic shelters provide sufficient surface to locate solar collectors that absorb sun radiation. The glazing collects solar energy for the watery biotope inside the structure. The couple

[19] Robert Gilman, 1990, "An Interview with John and Nancy Jack Todd", http://www.context.org/ICLIB/IC25/Todd.htm , (accessed June 2006).
[20] Nancy Jack Todd and John Todd, 1984, *Bioshelters, Ocean Arks, City Farming: Ecology as the Basis of Design,* San Francisco: Sierra Club Books.

designed the bioshelters with the geodesic expert J. Baldwin. They developed a material named Tefzel, a pillow-shaped glass that absorbs ultra-violet rays, solar energy increasing resistance against diseases of their living members. According to Todds, their shelters work like living machines, resembling those of Fuller's dwelling machines, for their providing a mechanically controlled environment while housing their watery ecosystems (Fig. 4.9).

Indeed, the 70s quest for self-sufficiency in energetic terms set the grounds for architects' being involved with the earthly self-regulation today. The architectural research projects that were pursued with a support from scientific and technological investigations helped in making the built works ecologically efficient. The philosophical outlook provided by the systems architects of the 60s supported those who prefer to practice architecture with an awareness of environmental issues. As mentioned earlier, such case was Sim van der Ryn, who is still utilizing the equilibrium view of the systems approach in his green practices. Seemingly, Todds' bioshelters take shape with the benefit from Buckminster Fuller's systems philosophy and his energetic-synergetic geometry. Indeed, Fuller's synergetic approach to nature has been followed not only by the Todd couple, but also by others who are involved with the technicist side of green innovation. Therefore, the following paragraphs will be about those who follow Fuller's environmentally consciousness at the technicist level.

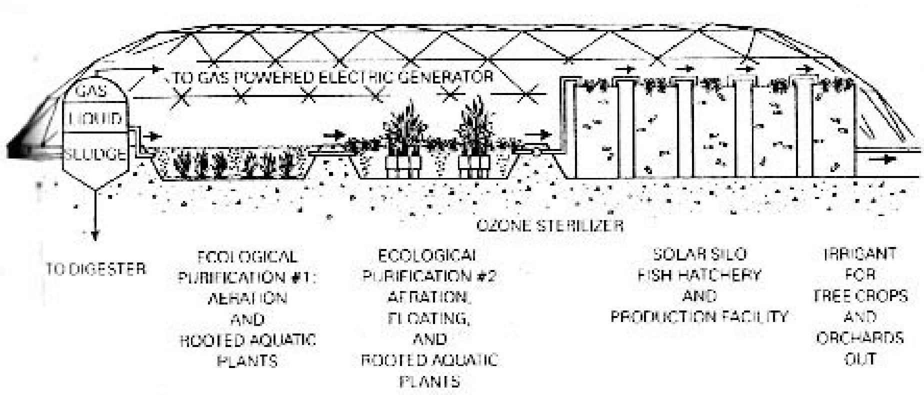

Fig. 4.9. The basic working system of the bioshelters.
Source: Nancy Jack Todd and John Todd, 1984, *Bioshelters, Ocean Arks, City Farming: Ecology as the Basis of Design,* San Francisco: Sierra Club Books, p.74.

4.1.4. Grimshaw's Biomes of Eden

Today, architects do not seek for a theoretical consistency in their looking at environmental subject-matter; rather they aim at offering as much practical solutions as possible to make their architecture a contributor of planetary healing. Therefore, we experience the recycling of theories and philosophies provided by the systems architects of the 60s. Such figure who contributes to this reprocessing is the English architect Nicholas Grimshaw. He himself was the witness of the social tendency towards looking at every phenomenon through the systems filter at that era. Indeed, as mentioned in the Third Chapter, Grimshaw was critical to this social current as he believed that architects are inherently involved with systems thinking as their profession necessitates the systematization and organization of their working methods. Despite that fact, Grimshaw, in an interview, mentions about his concern of the architectural production methods that were developed through the systems approach at that era; of the ways in which hardware elements are combined with reference to the general constructional principle of a building.[21]

[21] Enrique Walker, "Interview with Nicholas Grimshaw", in Hugh Pearlman, 1998, *Equilibrium: the Work of Nicholas Grimshaw,* London: Phaidon Press, p. 247.

Indeed, Grimshaw seems to follow the systems thinking inherently. For instance, as he informs us, he gives importance to the interdisciplinary research and investigation processes that is pursued by using technology and know-how.[22] The working teams are assembled in Grimshaw's office under groups of different ages and social genres. As it was discussed earlier, systems scientific research is achieved through the collaboration of people from diverse professions as well. Moreover, according to Grimshaw, diversity of people in the working process is one of the means leading to "a state of equilibrium", which he puts as "a state of poise resulting from a balance of energies" in architectural practice.[23] Hence, Grimshaw finds the diversity of professions as the means to lead to equilibrium in the architectural environment. Such idea comes certainly from systems ecology. As mentioned in the Second Chapter, diversity of living systems is considered by the systems ecologists of the late 60s as the means leading to an equilibrium environment. Grimshaw seems to construct analogies between natural and human ecosystems in this sense; the more communication takes place in a particular context, the more efficient it is. Note that the similar strategy exited in Van der Ryn case; like Grimshaw, he puts emphasis on the diversity of social groups in his urban designs.

Furthermore, Grimshaw draws upon six principles that are concerned with environmental responsiveness in his designs, and they are not far from the systems strategies either.[24] The first strategy is related with, as he puts, building and environmental management. He believes that the monitoring of the environmental conditions inside the building is the means that assures the environmental appropriateness of a design. As mentioned in the Second Chapter, the managerial attitude is one of the currents being inherent in the systems approach; i.e. the control of the closed systems through the help of science and technology was believed to be promises of a steady-state development.

[22] Nicholas Grimshaw, "Foreword", in Pearlman, 1998, p.7.
[23] Grimshaw in Pearlman, p.7.
[24] Grimshaw in Pearlman, pp. 240-245.

The second strategy, according to Grimshaw, is related with spatial organization that enables future change in the general arrangement of a building. He puts that the hardware system of a building should be designed in such a way that the elements are open to ore assembly in diverse volumes in a built space. The rearrangement of elements in a building is helpful in the avoiding of further requirement of architectural materials, which their production is detrimental to environment as they consume nature's resources. "I have always subscribed to the notion of buildings as organisms which respond to change", he told in the same interview.[25]As mentioned in the second chapter, the modification and change in the internal arrangement of a system is presupposed in the systems sciences as well. A living entity is assumed to arrange its own steady-state development in order to adapt itself to the outside contextual requirements. Hence, an entity which completes its evolutionary adaptation was supposed to be the one that reached to an equilibrium state.

Accordingly, his third scheme is enhancing the social means of communication in the process of design and realization. Grimshaw states that he tries to arrange the built volumes such that they are open to public spaces in a way to increase its communication with people, yet close to transportation systems. Indeed, systems ecologists presupposed the enhancement of communication systems for a steady-state development as well. They assumed that the more communication between the members of an ecosystem, the more this ecosystem is well equipped for survival.

Grimshaw's fourth strategy is the enrichment of recreational activities in order to reconstruct the lost relations of humanity with nature. For that, he puts emphasis on the redevelopment of the naturally devastated areas and utilizes them especially for human recreational activities. He puts that his Eden project in particular, which will be discussed in the following paragraphs, was realized by taking account of such purpose. Systems scientists are also concerned with the reconstruction and renewal of a particular system to regain its bioregenerative peculiarity. The earthly remedial was assumed under the construction of analogies with a machine. For instance, the

[25] Walker in Pearlman, p.246.

ecosystem ecologist Eugene Odum put that the ecological bookkeeping should be as easy as the repair and renewal of a car.

Consequently, Grimshaw's fifth strategy is to contribute to the sharing of knowledge among societies in general. Indeed, his aim is to consider such purpose as a part of his global strategy for enhancing environmental consciousness, rather than making it as a part of his architectural design achievements. In this sense, he tries to render his work as much as being part of the global communication and network systems in order to share his accomplishments to the public. Lastly, being part of a global strategy again in this respect, his sixth principle is the bridging connections between the developed and undeveloped world in order to disseminate knowledge of environmentally appropriate means of human survival. The intensification of knowledge shared is a strategy in systems approach as it is in architecture. This assumption is the canon of the theory of information being inherent in the systems approach, which supposes that the more communication takes place inside the system; the more the system assures its stability.

Grimshaw puts his architecture to the service to develop communication network for the steady-state human ecology. His British Pavilion for the Seville Expo in 1992 can be considered as a commencement of his efforts in his respect. Basically, it is a temporary building that comes forward with its passive cooling systems that counterbalances the hot climate of the region. The cooling systems, which are water-based and are generated by the photovoltaic energy, take out the warm weather inside the spaces. The warm air is cooled at night and released out during the day. The shading devices attached to the façade prohibits the sunlight in case of intensity, with the help of the energy generated from photovoltaic cells on the rooftop. The material hardware was recycled for its utilization in another context after the exhibition is closed (Fig. 4.9.)

Fig. 4.9. *Nicholas Grimshaw,* British Pavilion, *Expo 1992.*
Source: Gissen, David (Ed.). *Big and Green: Toward Sustainable Architecture in the 21st Century.* New York: Princeton Architectural Press.

The most significant achievement of Grimshaw is his Eden project located in an area 8 km remote from Cornwall, England.[26] Being part of the Millenium projects of Great Britain, it is a botanical garden enabling visitors to inform about plant populations belonging to the diverse climatic zones of the world. The garden has spaces providing scientific investigations on plant life and their medicinal use. The project is realized out of the assembly of geodesic units that envelop closed plant ecosystems. Ranging in size from 18m to 65m radius, the geodesic structures are supported by tubular sections of galvanized steel. The steel structures are hexagonally arranged to carry air-inflated transparent pillows in plastic material. In the book entitled *Sustaining Architecture in the Anti-Machine Age*, Grimshaw clearly states that he followed Buckminster Fuller's approach in enveloping large areas with a minimum structural support, thus, he benefited from triangular-shaped geometries in this respect.[27] "The final scheme represents the perfect fulfillment of Buckminster

[26] The information on the Eden project is complied from the following book: Ian Abbey and James Heartfield, 2001, *Sustaining Architecture In the Anti-Machine Age,* London: Wiley Academy, pp. 32-36.
[27] Grimshaw in Ian Abbey and James Heartfield, 2001, p. 32.

Fuller's vision - the maximum enclosed volume within the minimal surface area", he writes[28] (Fig. 4.10).

Fig. 4.10. *Nicholas Grimshaw,* The Eden project, *Cornwall, 2001.*
Source: "The Eden Project",
http://www.beautifulbritain.co.uk/images/edenproject/eden_project7.jpg (accessed mar 2006).

The geodesic structures dome over the plant species belonging to the tropical and moderate climates of the world regions. Grimshaw calls his transparent greenhouses "biomes", a terminology borrowed from the discipline of biology, indicating the entire community of living organisms in a particular ecological environment. The geodesics of the botanical garden are located in 15 hectares of land rehabilitated from an unused clay mine. Indeed, the rehabilitation and reuse of a devastated area in the countryside corresponds to Grimshaw's fourth principle concerning the reconstruction of the lost relations of humanity with nature. On the one hand Grimshaw's efforts to renew the unused areas as a countryside attraction echo the arcadian type of achievements of the Romantics of the nineteenth century. As the

[28] Grimshaw in Ian Abbey and James Heartfield, 2001, p. 32.

environmentalist thinker Peter Hay informs us, the self built timber cabinets constructed in the countryside, as part of the nature appreciation project of the Romantics, became one of the samples for the environmentalist movements of the late 60s.[29] Hence, Grimshaw, with his geodesics of the countryside, which is already an attraction place for those who would like to get closer to nature's benefits, seems to be influenced from this Romantic current.

But on the other hand, the sites in which the geodesic domes will be located are determined with the help of computer software that incorporates a modeling technique determining the most beneficial areas to capture sunlight for diverse climates. The material used in the geodesics, which is ETFE (Ethylene Tetra Fluoro Ethylene), operates like Todds' Tefzel glasses, and capture sun radiation for the plant ecosystem. The climate inside the structures is controlled via a computer tracking system, which operates like a thermostatic unit arranging the input temperature with regard to the output energy. Rainwater is recycled for its use in assuring the humid weather inside the biomes. "The project is also an example of how an environmental management system can be used to assess design development", Grimshaw writes.[30] With the application of computer tracking methods in his designs, Grimshaw in a way followed Fuller's early ideas on controlling the geodesic-domed environment by means of computer software.

Grimshaw benefits from the systems discourse of the 60s in his providing practical solutions without falling into abundant discursive speculation. He reveals his reluctance from the theoretical discourse of architecture and his interest in practicing in one of his writings.[31] "We are not a theoretically driven practice-we like to build. It is our skills, perhaps our approach", he writes.[32] His practical searches in architecture range from his geodesic techniques to his methods on the systematization of environmental management and control. Recently, he is interested

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[29] Hay, Peter. 2002. *Main Currents in Western Environmental Thought.* Bloomington and Indianapolis: Indiana University Press, pp.11-16.
[30] Grimshaw in Ian Abbey and James Heartfield, 2001, p. 32.
[31] Grimshaw in Pearlman, 1998, p.7.
[32] Grimshaw in Pearlman, 1998, p.7.

in developing techniques to assess the environmental impacts of a building prior to its completion. With the application of his innovative methods of environmental impact assessment, he shares his practical knowledge on systems research and analysis within the current green architectural arena in this sense. The technology he developed received a certificate from an international establishment, which is specialized of environmental management systems. With that technology, the design phases of the projects are evaluated by using green color labels that indicate the degree of the harm made to the natural environment. The darkest one indicates the most benign in design practice. In this sense, Grimshaw, although eschews from discourse, is a perfect supporter of the systems approach by means of practice.

4.1.5. Foster's Vertical Geodesics

Todds' bioshelter units that provided a sample for those who would like to envelop closed ecosystems was already discussed. The Todd couple worked with the dome expert J. Baldwin in the 80s to ease the sunlight gain of their geodesic structures. Here, transparent plastic pillows, in other words Tefzel materials, which easily capture sunlight without any deformation, are mounted on the steel frames. Two decades later, another material that is lighter and more efficient was introduced and used in the Grimshaw's Eden project. The ETFE panels in particular, are double skinned glasses which also have a pillow shape. They further the efficiency of Tefzel panels in their trapping of sunlight and keeping the heat in long periods. Its recyclable peculiarity renders its re-cladding after the building completes its period of use.

Indeed, we owe the improvement in the geodesic greenhouses to the early unsuccessful achievements. The geodesic dome constructed in the Missouri Botanical Garden in St Louis, USA in the 1960 is significant for its being the first that houses a plant ecosystem.[33] Inspired by Fuller in particular, the 70 feet high dome, coined as “Climatron” by the garden director, is still doming over the plant species of tropical climate. The geodesic geometry was selected for the reason of its facilitating the efficient means climate and humidity control of the plant ecosystem. It provides a large space that the visitors enjoy, especially giving the sense of being in a place similar of a tropical jungle. However, the most significant issue making the dome well-known is not its being one of the major tourist attractions, but its high cost renovation that it went through two decades later due to its discolored plexiglass panels and warped aluminum frames causing heat escape and leakage. During the renovation, the plastic panels were replaced by glass ones that caused further warping of its aluminum structural frame due to the increased weight. Therefore, the engineers doubled the framing of geodesics as a precaution against stability (Fig.4.11).

Fig. 4.11. *Paul Londe,* Climatron, *Missouri, USA, 1959.*
Source: Walt Lockley, 2002, “The Climatron”,
http://www.waltlockley.com/climatron/climatron.htm, (accessed January 2006)

[33] The information about the Climatron geodesic was gathered from the following websites: Walt Lockley, 2002, “The Climatron”, http://www.waltlockley.com/climatron/climatron.htm, (accessed January 2006) ; “Exploring the Missouri Botanical Garden”, 1996, http://www.slfp.com/Shaws081005.html (accesed January 2006); “Climatron”, 2000, http://www.pbs.org/wgbh/buildingbig/wonder/structure/climatron.html

However, the failure of the first geodesic large span did not prevent its innovator Buckminster Fuller to make further achievements on the structure at that period. For instance, he searched on the possibility of making a domed-over office building with his young colleague Norman Foster in 1971.[34] He coined his project “Climatroffice”, a name he inspired from the aforementioned Climatron building. Basically, the geodesic dome of the Climatroffice operated in a similar way of its functioning in greenhouses. It facilitated the climate control of the place more than any other large-scaled spans. The gardens situated in the floors generated a microclimate. The hexagonal arrangement of the outer skin allowed for more transparency. However, the technology at that time did not allow generating the double-curvature cladding (Fig.4.12).

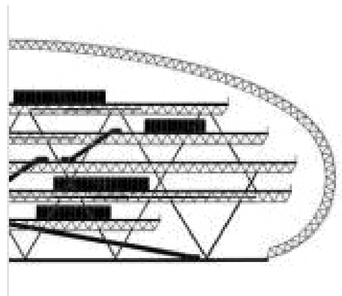

Fig. 4.12. *Buckminster Fuller and Norman Foster,* Climatroffice, *1971.*
Source: “Lungs of the Library”, 2006,
http://www.metropolismag.com/cda/story.php?artid=1742 (accessed March 206)

Basically, Climatroffice was not the only geodesic project that the pair worked together.[35] They put into place certain realized works alongside the experimental

[34] The information about the Climatroffice building was gathered from the following websites: 1999, “Pritzker Laureate Norman Foster”, http://www.pritzkerprize.com/mediakit99.htm (accessed January 2006); “Lungs of the Library”, 2006, http://www.metropolismag.com/cda/story.php?artid=1742 (accessed March 206)
[35] The information about the Climatroffice building was gathered from the following websites: 1999, “Pritzker Laureate Norman Foster”, http://www.pritzkerprize.com/mediakit99.htm (accessed January 2006); “Expo 67”, 2006, http://en.wikipedia.org/wiki/Montreal_Expo (accessed January 2006).

ones. Before that, they designed geodesic structure for the US pavilion for the Montreal Expo of 1967. The pavilion was famous especially because of its usage in the scenes of two futuristic films after it went through a serious fire which destroyed the acrylic outer skin of the dome. The scenes depicted the post-apocalyptic age that inaugurated after the planet earth is subject to an environmental disaster (Fig. 4.13).

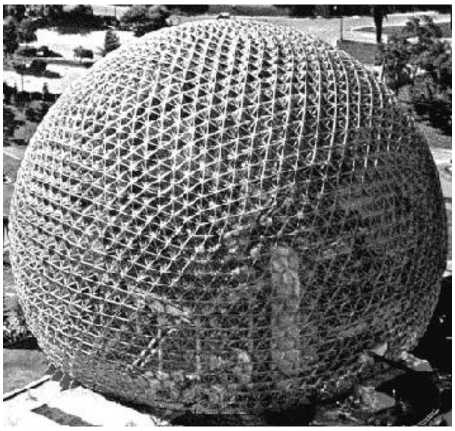

Fig. 4.13. *Buckminster Fuller and Norman Foster,* Montreal Expo Dome, *1967.*
Source: "Buckminster Fuller Master Index", 2005,
http://www.buckminster.info/Pics/Icosahedra/Icos-Dome-Expo67-Aerial.jpg
(accessed March 2006).

Fuller and Foster continued their collaboration for 15 years until the death of Fuller in 1983. "The thing about Bucky was that he made you believe anything is possible", writes Foster in an article in which he discussed his works for the commemoration of his being a Pritzker Laureate in 1999.[36] Hence, Foster owes his current green achievements to the early experiments in which he worked with Fuller in his respect. He is a well-known architect for his works drawing upon green means of architectural development besides his other achievements. His projects are in a way the solid evidences of the issues that he discussed with Fuller regarding the passive

[36] "Pritzker Laureate Norman Foster", http://www.pritzkerprize.com/mediakit99.htm, (accessed January 2006).

environmental control at that era. Foster began highlighting the Fullerian means of environmental management in his architecture with his Commerzbank Office building in Frankfurt, Germany that was completed in 1997.[37] Being the tallest skyscraper of Europe with his three hundred meter height, the headquarter office is significant for its enabling climate control through passive ventilation systems. The one-storey high double skin glasses can be controlled manually and mechanically at the same time. The office staff can be in charge of the climate inside by opening and closing the windows except the cold days. The thermostatic arrangement drives the mechanical system of the window openings for closure, in case there is decline of temperature. Foster applied the Fullerian principle of passive environmental control by introducing greenery under the large span in the Commerzbank project. Basically, he designed a large atrium in which air flows through office spaces. The air inside the glass atrium is cooled through spiral-sectioned green areas that are rhytmically repeated in various heights. The functional attributes of plant species determine the location of greenery within the skyscraper (Fig. 4.14).

Foster passively controlled the climate under large spans in his later creations as well. His renovation of the German parliament building is one his achievements in this respect.[38] He designed the dome that covers the main auditorium such that it provides passive ventilation. For that, he designed a large conical-shaped structure that is inversely assembled on the dome’s central axis. The window openings on the dome take out the used air from the auditorium spaces. The clean air is taken in from the existing vents of the building and transferred into the basement by mechanical equipment. It was returned to the parliament auditorium after it went through heating and humidification process. The energy necessitated ventilation systems are provided by the photovoltaic cells mounted on the roof. The mirrors mounted on the inversely applied conical structure carry the sunlight inside; therefore, reduce the energy used for artificial lightning. The clean air is either kept in the cooling equipments to be

[37] The information about the Commerzbank by Foster is gathered from the following book: Ed Melet, 1999, *Sustainable Architecture.* Rotterdam: NAI Publishers, pp. 46-49.

[38] The information about the German Parliament Building by Foster is gathered from the following book: Herzog, Thomas (ed.). 1998. *Solar Energy in Architecture and Urban Planning.* 2nd edition. Munich: Prestel, pp. 132-133.

used in summer or used for the purpose of heating the stored water on the basement to be used in winter. The building comes forward with its other environmentally-conscious attributes as well. The air and water is heated not by using non-renewable energy sources like fuel oil, but by a biodizel that is generated from a particular plant waste. This green heating process prohibits the release of harmful gases to the environment (Fig. 4.15).

Fig. 4.14. *Norman Foster,* Commerzbank Headquarters, *1994-1997.*

Source: Ed Melet, 1999, *Sustainable Architecture.* Rotterdam: NAI Publishers, p. 46.

Fig. 4.15. *Norman Foster,* German Parliament Building, *Berlin, Germany, 1993.* Source: Thomas Herzog, (ed.), 1998, *Solar Energy in Architecture and Urban Planning,* 2nd edition, Munich: Prestel, p. 132.

However, as Foster himself informs us, it is the 30 St Mary Axe building, in which the principles generated during Climatroffice experiment came into realization.[39] The headquarters building commissioned by the Swiss Reassurance Company is a 180 meter high tower containing offices, retail areas and a public plaza. It is a geodesic volume that goes towards vertical direction, rather than the horizontal one. It has a radial plan that widens as it rises and contracts when it comes to the top. The tower is supported by a triangulated steel structure mounted on the facade. As the structure enhances the rigidity by bracing the entire volume, the central core stays as a load-bearing element. Furthermore, the bracing gives way to both the column-free office spaces and the completely glazed façade.

The double glazed spiral bands mounted on the triangulated structures of the façade are the members of passive lightning and ventilation system. They allow the fresh air and natural light, which are carried to the office spaces via the help of mechanical

[39] The information about the building is gathered from Ian Abbey and James Heartfield, *Sustaining Architecture in the Anti-Machine Age,* London: Wiley Academy, p. 206-207.
Further information about the St Mary Axe building can be obtained from the following website: “St Mary Axe, Swiss RE Headquarters”, http://www.fosterandpartners.com/ (accessed March 2006).

equipments, to penetrate inside. The aerodynamically shaped volume helps this passive ventilation system by generating pressure differences in various parts of the building. Like the Commerzbank office building, the continuity of the entire structure is interrupted by means of atrium spaces that subsequentially repeat in a spiral-like configuration. The atriums contain green areas which help in the ventilation system. According to Foster, the greenery operates in a similar manner of the "lungs" of a living organism.[40] The fresh air produced by the plants is carried out to the entire building by means of the mechanical ventilation devices. The spirally escalated open spaces function as the gathering places for the office users. Furthermore, the Swiss RE skyscraper displays Foster's energy conservation principles that are first applied in the German Parliament building as well; that the excess heat produced are stored in the basement to be used for the heating and cooling purposes in the later season.

The design of the building was realized with the help of computer software. Parametric modeling in particular, which is originally produced for aerospace and automotive industries for the design of complex curved forms, converts the overall design into mathematical equations. The mathematical basis enables the modification of the design in general with regard to the change in any detail. Foster puts that the mathematical configuration, because it gives way to instant modifications in the entire structure, ensures the functioning of his design as a living organism. Furthermore, this modeling technique serves in searching for the possibilities of mounting the flat material members in a curved structure. Hence, with this project, Foster in a way realized Fuller's envisioning of computerized means of environmental feedback systems to the geodesic design and construction four decades later (Fig. 4.16).

[40] "St Mary Axe, Swiss RE Headquarters", http://www.fosterandpartners.com/ (accessed March 2006).

Fig. 4.16. Norman Foster, 30 St Mary Axe, Swiss RE Headquarters, 1997-2004. Source: "30 St Mary Axe", 2006, mhttp://en.wikipedia.org/wiki/30_St_Mary_Axe30 St Mary Axe, (accessed March 2006).

Recently, Foster has been working with the English environmental and building services firm founded by the engineer Guy Battle and the artist Christopher McCarthy for the proposal of New Globe Theatre on Governers Island, New York.[41] Foster's design is based on developing a theater building inside a five hundred year old castle situated on the island harbor. The theatre will be erected for putting up the scripts of Shakespeare into play. The area surrounded by the castle will be domed

[41] The further information on the New Globe theatre can be obtained at the following website: "New Globe Theatre on Governers Island", http://www.battlemccarthy.com/images/globearticle.jpg (accessed March 2006).

with a glass structure that enables a delightful perception of the harbor view. Foster collaborated with the Battle-McCarthy firm for the development of passive cooling strategies to a solid volume that will inevitably be heated due to the intensity of solar energy gained from the glass rooftop. He takes advantage of the river water to cool the entire volume with the aid of passive ventilation. Furthermore, he intends to install computer-controlled solar tracking systems that would drive the mechanics of the façade shading to open and close in case of the intensity of sunlight (Fig. 4.17).

Fig. 4.17. *Norman Foster,* New Globe Theatre on Governers Island, New York, *2006.*
Source: "New Globe Theatre on Governers Island",
http://www.battlemccarthy.com/images/globearticle.jpg (accessed March 2006).

Hence, Battle McCarthy is specialized in generating thermal mass cooling systems with the help of computer software for environmental efficiency. It is an England-based engineering firm that is counseling architects in environmental management and control systems. It has recently consulted the SOM architectural firm to design the ARB Headquarters located in Riyadh, Saudi Arabia according to passive cooling principles.[42] They developed labyrinth in the building's vents for clean air gain. The

[42] The information about the ARB Headquarters Building can be gathered from the following website: "ARB Headquarters", http://www.battlemccarthy.com/images/ARB.jpg (accessed March 2006).

hot air captured in the labyrinths was cooled by the water cascade situated on the bottom of the vent. The cool air is released during the day via mechanical equipment.

The Battle McCarthy firm is especially preferred by architects who are open to interdisciplinary collaboration to work on the environmental self-sufficiency. The firm occasionally claims expertise from the aeronautical and space engineers in endowing the buildings environmentally-appropriate in technological manner. Accordingly, the engineers inform us in the book entitled *Sustainable Ecosystems* that material treatment is replaced by immaterial systems in the contemporary means of treating a building.[43] The materials of the spaceship industry that were popular in the 60s were replaced with the material simulations rendered on the computer software. The simulation methods enable experimenting with the material to test on the impact of wind and light before it was clad to the building in the construction process.

In this sense, Foster's achievements inform us about the latest means of producing architecture through the interdisciplinary research and investigation processes that are pursued with the help of latest technologies. As mentioned in the second chapter, both the collaboration of various disciplines and the computerized control were the principles suggested by the post-war systems scientists regarding the endowment of a managerial attitude towards natural phenomena. Ecosystem scientists abundantly applied the aforementioned strategies in hypothesizing the natural environment as a closed system of spaceship that efficiently puts its input and output mechanisms into play for being in a steady-state. As displayed in the Foster case, the recent architectural developments seems to conform to this envisioning of nature as a closed spaceship by erecting more building spaceships that conditions its own environmental integrity without the development of any contextual relations in an urban fabric.

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[43] Battle, Guy and Christopher McCarthy, *Sustainable Ecosystems and the Built Environment,* London: Wiley Academy, p.10.

4.1.6. The Contemporary "Arcologies" of Richard Rogers

Among those who endow a technicist perspective for human survival today, Richard Rogers may be the one who prefers to embellish his sustainability discourse with doomsday views. His common peculiarity of his published works is that they habitually inform about the alarming state of the earth due to intense exploitation. Such statements are familiar in his writings:

> Buildings are responsible for 50% of the world's generation of CO2. How can design mitigate this alarming statistic and address the fact that climate change in general is threatening the future existence of mankind? Research and delivery of ways to avoid this catastrophe must be our primary aim.[44]

Such an alarming discourse may be usual for the one who belong to the generation raised by reading Rachel Carson's famous book *The Silent Spring* that contains warnings against harvesting by chemicals.[45] Indeed, as Rogers put in his statement, architecture is the other harmful practice alongside agriculture. Being 50% responsible for deterioration, architects have to contribute in salvaging the earth. According to him, they have to attain a comprehensive approach based on holistic thinking. Hence, like his aforementioned contemporaries, he has certain suggestions for that.[46] First of all, following Rachel Carson's avoidance in using toxic chemicals in human practices, he eschews from utilization of materials like asbestos, lead, calcium silicate or polyurethane in his buildings. Secondly, he puts that buildings have to operate in a self-sufficient manner in the use of energy and resources. Every built form must recycle the input energy generated from the non-renewable matter. He particularly stresses that he was taught on the architectural efficiency in the use of resources through the work of Buckminster Fuller.[47] Rogers follows Fuller's ideas in

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[44] Richard Rogers, 2005, "Sustainability", http://www.richardrogers.co.uk/render.aspx?siteID=1&navIDs=1,3,1179, (accessed March 2006).

[45] Richard Rogers himself emphasizes that Rachel Carson is influential in the development of his discourse. See Rogers, 2005, "Sustainability", http://www.richardrogers.co.uk/render.aspx?siteID=1&navIDs=1,3,1179, (accessed March 2006).

[46] Rogers, 2005, "Sustainability".

[47] Interview with Richard Rogers by Nina Rapoport, in David Gissen, (ed.), *Big and Green: Toward*

considering every natural and man-made artifact as closed spaceships that efficiently uses energy and resources for long time endurance on earth. Indeed, in his book entitled *Cities for a Small Planet* published in 1997, Rogers begins his ideas with a citation from Fuller's book entitled *Operating Manual for Spaceship Earth,* which is about the scarcity of resources that humans need to go along on our planet.[48] Thirdly, he puts that architects should get the expert advice on passive systems through interdisciplinary collaboration.[49] Fourthly, architects should use recyclable or durable materials like steel, concrete, glass or aluminum. The materials should be modularly structured to give way for their replacement in case of damage and for their use in another context after the building completes its life. Lastly, the spatial configuration of the buildings should be flexible enough to meet the change in the functional requirements in the passage of time. Hence, the design of the mixed use spaces is one of the ways that lead a flexible architectural development.

Rogers' journey to ecological sustainability begins mainly with the design of an office building for the Lloyd's Insurance Company that was completed in 1996.[50] The building has a significant place in the London city panorama by means of its shape resembling a gigantic machine. Indeed, the elements that make up this building are arranged in a way similar to the operation of a mechanical entity. The industrially manufactured parts are assembled such that they are open to replacement in case of decay. The building has certain other environmentally-conscious attributes which are insignificant due to its belonging to the period in which Rogers initiated designing in an environmentally-appropriate way. For instance, the spaces are flexibly arranged to meet diverse functions. They are open to rearrangement in case there is a change in the function in the course of time. The glazed façade is triple-layered in order to act as an insulating element. The triple shinned glazing reduces energy saved for heating the entire building. The reinforced concrete ceiling is porously designed to absorb

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Sustainable Architecture in the 21st Century. New York: Princeton Architectural Press.
[48] Richard Rogers, 1997, *Cities for a Small Planet,* Philip Gumuchdjian (ed.), London: Faber and Faber, p. p.1.
[49] Rogers, 2005, "Sustainability".
[50] The information from the building is compiled from Rogers, 1997, p. 96.

cool air during the night. The cooled air is released via mechanical apparatuses at the daytime (Fig. 4.18).

The most significant example of Rogers' sustainable architectural creation is the Law Courts of Bordeaux completed in 1998.[51] The building is consisted of a glass clad office building and eight courtrooms of cedar material located under the copper roof structure. The entrance is from the public hall situated at the side which faces the courtroom. The reinforced concrete public space provides interrelations with the existing urban fabric and offers a meeting point where lawyers meet their clients. The visitors enter via the stairs that penetrate the courtrooms from the middle of the building. The courtrooms are lifted from the ground to enable lower air currents to cool the building belonging to the Bordeaux region. The double layered glass façade contains openings that can be controlled by the office staff. The courtrooms have an onion shape reminding one of the traditional oast-houses. The rooftop is truncated to allow the long time endurance of the cool air currents which enter the building from the floor level grid. The air is cooled by the water cascade situated at the bottom level of the public hall. Furthermore, the cool air is used also for ventilating the glazed office spaces. The grilled rear façade of the office spaces help for taking in the cool air from the courtrooms. The air is distributed to the office area by means of the concrete floors that absorb the air during the night.

[51] The information on the law courts was gathered from the following source: Ed Melet, 1999, *Sustainable Architecture,* Rotterdam: NAI Publishers, p. 108.

Fig. 4.18. *Richard Rogers,* Lloyd’s Insurance Company Building, *London, 1986. Photograph by the author.*

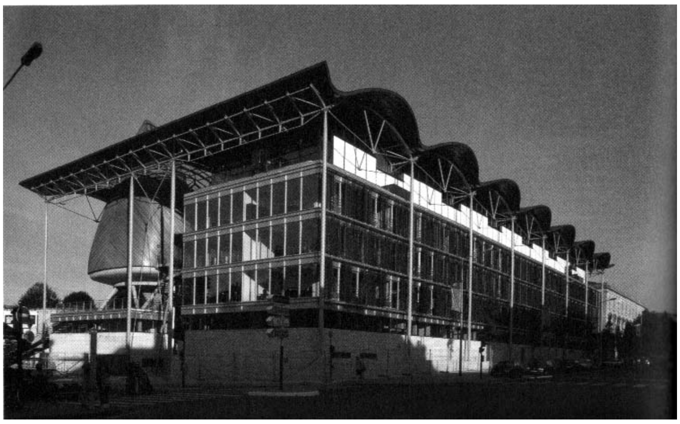

Fig. 4.19. *Richard Rogers,* Law Courts, *Bordeaux, 1992-98.*

Source: Ed Melet, 1999, *Sustainable Architecture,* Rotterdam: NAI Publishers, p. 108.

Recently, Rogers completed the National Assembly building located in Cardiff Bay, Wales. The building is designed in a similar approach with the design of Bordeaux Law Courts.[52] It is composed of a large auditorium for the Welsh Chamber, administrative spaces and exhibition areas roofed under a copper canopy. The parabolic-shaped auditorium of timber material is situated at the center and is surrounded by the administrative and public spaces. The entrance is via the public hall that is raised above the ground floor level to enable daylight entrance to the administrative spaces at the basement level. The timber auditorium has such shape as it is used as a passive system for air circulation. According to Rogers, it operates in a way similar to the lungs of an organism in its driving of energy currents. The air that is subject to these currents is cooled at the basement level of the public hall. The rainwater is collected to be used as a grey water source in toilets and landscaping. "Biodizel", which is a renewable energy source generated out of plant waste, is developed in the boilers in order to heat the entire building. The materials used for construction is selected among the ones who have a certificate of sustainability. The sustainable attributes of the materials are evaluated by means of the degree of its reduction of energy being wasted during its manufacturing and transportation. The building received the Building Research Establishment's (BRE) highest award for sustainable building construction. It was selected because of its energy efficient passive systems that are put into place during the construction and maintenance processes.

Rogers is also significant in the architectural arena for his sustainable proposals for an urban environment that resembles the ones developed by the architect Paolo Soleri decades ago. In the book entitled *The Operating Manual for Spaceship Earth*, Rogers asserts that urban areas are the loci for environmental deterioration for their lack of feedback mechanisms in recycling the output energy and materials being wasted due to the inappropriate consumption patterns.[53] "Cities have become the

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[52] The information on the National Assembly building is complied from the following website: Richard Rogers, "National Assembly for Wales", 2005, http://www.richardrogers.co.uk/render.aspx?siteID=1&navIDs=1,4,24,245,1182 (accessed March 2006).
[53] Rogers, 1997, pp. 24-97.

parasites on the landscape –huge organisms draining the world for their sustenance and energy: relentless consumers, relentless polluters", he writes.[54] According to him, cities should be considered as closed spaceships being subject to circular metabolism rather than the linear one. He was basically influenced for the approach put forward the scientist James Lovelock that considers our earthly systems operating under a superorganic power. With a citation from the urban planner Herbert Girardet, he puts that cities should also be considered as metabolic entities driven by the superorganic system of our planet earth.[55] Therefore, we should find ways to conform to this superorganic system, rather than to oppose it.

In the book, he emphasizes that he considers the real wealth of humanity as natural resources that sustain human life, such as water, wind and sun, contrary to the wealth in monetary terms. Furthermore, like Fuller, he displays a belief in the human intellectual power for operating the regenerative system of our planet. He puts that although public participation is important, it is significantly the individual will that plays a major part in regaining the environmentally-efficient patterns of humanity. Therefore, every citizen should bear equal responsibility in rendering urban areas circularly metabolic. According to him, technological development is the chief supporter of humanity in their generating energy efficient urban systems. He writes:

> …we have never abandoned our belief that it is the imaginative leap associated with new technology which may be the solution to the problems of our planet. We envisage buildings which possess 'an electronic nervous system', controlling services, tailoring heat and ventilation, switching lighting on and off and feeding off solar wind and wind power. That said a key issue is persuading commercial clients to buy into low energy solutions.[56]

Rogers' well-known urban proposal in Lu Jia Zui district of Shanghai, China is significant for its display of technological self-sufficiency into a compact

[54] Rogers, 1997, p. 27.
[55] Rogers, 1997, p. 29.
[56] Rogers, 2005, "Sustainability".

development.[57] Designed as a district of Shanghai, the proposal is the evidence of Rogers' following Soleri in its compact scheme. Like Soleri before him, he believes that a compactly configured urban structure is more energy efficient when compared with the decentralized city scheme. As a conformance to the compactness concept, the plan is radially designed with greenery at the center. The buildings surrounding the greenery in a hierarchy of level and scale are designed as an appropriate way for a mixed use development as they contain office, commercial and habitation spaces under their volumes. The radial development around the greenery is divided into six rings of intensity. The most intense development ring is the one that contains buildings with the less height. The distribution of densities into a hierarchical order maximizes the daylight penetration into the buildings, thus saves energy.

The design of vehicle and pedestrian circulation pathways are for enhancing energy efficiency under the compact scheme. The circulation is designed under a pedestrian-friendly system. The car use is discouraged by forbidding vehicle entrance in certain areas and pedestrian walk is encouraged by developing short walking distances between the destinations. The transportation between the district and the city of Shanghai will be made via railway that cuts across the radial plan from the north-west to the south-east direction. The railway line is also bisected through cable car ways, pedestrian and bicycle tunnels. Energy efficiency is spawned under other strategies for a green design as well. The energy generating systems of Lu Jia Zui district was assumed to be computer- controlled. The methane generated from garbage waste was planned to be used to drive the heating systems. The collected rainwater would be used for the greywater of the city. The biological waste burned via the use of energy generated from photovoltaic cells would be used for heating the entire city (Fig. 4.20).

As a result, Rogers sustains the achievements of his 60s predecessors by envisioning built forms as closed spaceships that are operating under the metabolic urban system

[57] The information on the Shangai urban proposal is gathered from the following source: Richard Rogers, 1997, *Cities for a Small Planet,* Philip Gumuchdjian (ed.), London: Faber and Faber, pp.40-53.

and that are derived by the superorganic power of the planet earth in a larger scheme. As his works display, he conforms to his contemporary technicist colleagues in focusing on the technological side of architecture. He refers to implant his works with technological apparatuses that help to sustain self-sufficient systems. Rogers in a way contributes to the realization of 60s utopias by introducing on the ecologically-sound patterns of urban living. Rather than providing a coherent philosophy, he prefers to use the bits and pieces of the systems ideas which were developed decades earlier on the cybernetic means of development.

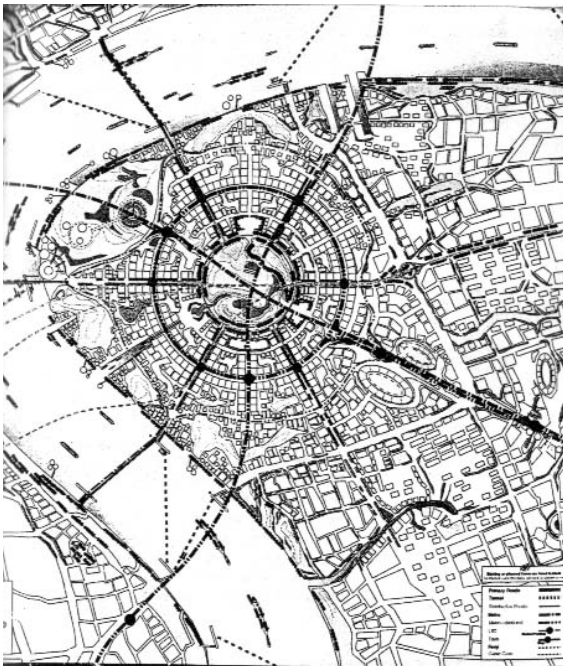

Fig. 4.20. *Richard Rogers,* Shanghai Master Plan, *1992-1994. (unbuilt).*

Source: Richard Rogers, 1997, *Cities for a Small Planet,* Philip Gumuchdjian (ed.), London: Faber and Faber, pp.47.

4.1.7. The Skyscraper as an Ecosystem: Bioclimatic Architecture of Kenneth Yeang

Among those who are interested in setting forth the technological aspects of their green works, Ken Yeang is the one implanting his practice with a philosophical background. He is well-known in the architectural arena not only with regard to his environmentally-appropriate high-rise works, but also with his publications based on the framework of post-war systems ecology. His writings are the clear evidences of the continuity of the equilibrium perspective of the systems sciences in the architectural discipline as well as other contemporary architects who are still involved with the steady-state systems vision. However, Yeang is the only one who entirely reappropriates the arguments of the ecosystem ecology alongside Van der Ryn, who gives slight information.

For instance, his book *Designing with Nature* can be considered as the architectural complement of the *Fundamentals of Ecology*, which contains a collection of the ecosystem ecologist Eugene Odum's ideas.[58] In the book, Yeang often uses terminology developed by post-war ecologists in general, such as "resilience, applied ecology, holism", while situating his architecture on a philosophical basis. Indeed, his appeal to systems ecologists has another reason alongside his quest for a philosophical coherence; he tries to inform architects on the human impact of entropy increase as he believes in their unawareness on the subject. According to him, architects contribute to the entropy acceleration by ignoring the holistic connections with our life supporters. They consider their projects solely as members of the nearby environment, despite the fact that they belong to the world's ecosystems. Yeang warns us that what is performed in the context of production affects a larger habitat. Architects have a responsibility to be involved in earthly repair and renewal, as their built creations are the major supporters in its annoyance.

[58] Ken Yeang, 1995, *Designing With Nature: The Ecological Basis for Architectural Design,* New York: McGraw-Hill, Inc.

He believes in maintaining the order and balance of natural systems. Hence, Yeang should have thought that being informed on systems science may wipe away this reductionistic approach of architects. In the book, he gives a brief explanation about the thermodynamic situation of our degraded environment. He enlightens about the necessity of keeping our earth in a negentropic state. He mentions about how stability is important for preserving biological diversity, despite that current investigations proved that it is not a prerequisite. As mentioned in the second chapter, the public education on environmental degradation emerged in the postwar years through the scientists investigating on the devastated effects of the Second World War. Recently, that mission seems to be resurrected by Yeang, this time in favor of architects.

In the beginning of the book, he puts that those who are misinformed attain three means of extremist positions towards ecological subject-matter.[59] One is, as he puts it, the "doomsday" position represented by the pessimists, who believe that the earth will collapse when its entropy reaches to a maximum degree. The other is represented by the optimists that believe in the earthly remedial through the proper application of technology. And the last one is, as he may have mentioned that way, the nihilists, who do not consider about the involvement with any effort for the reason that there is not any consensus on the future state of earth. According to Yeang, in order not to get trapped in those positions, every architect should be trained in ecology prior to being involved in design. The architect should be aware of the entropic processes of nature in order to avoid its acceleration by architectural interference. However, as mentioned in the second chapter, the doomsday, the technicist and the nihilist views are always existed in the systems science as well. As mentioned in the second chapter, Donald Worster, the historian of environmentalism puts that systems scientists did not attain a consensus on the future state of earth, therefore preferred to nurture their discourse by attaining both the technological optimist and doomsday pessimist positions.

[59] Yeang, 1995, p.2.

The main idea of the book *Designing with Nature* is that buildings are the members of the world ecosystems; therefore they should conform to the thermodynamics of energy exchange. He analogizes the building with an ecosystem in this respect: "The built environment is analogous to a living system, which survives by importing energy and matter from its environment in one form or another and then exporting back into its environment after use" he writes.[60] He believes that buildings have their particular "metabolism" utilizing input resources and expelling them to the outside. Therefore, it is responsibility of an architect to arrange the building such a way that it works like the metabolism of natural systems, meaning as much negentropic as possible.

Yeang informs about what ecosystem is at the beginning of his book in this sense. He introduces the ecosystem ecologist Tansley's coining of the term and Odum's modification decades later.[61] He informs that the basic task of an ecosystem is the maintenance of the stable flow of matter and energy with the help of such processes as metabolism, photosynthesis and symbiosis. He notifies that mutual interaction, rather than competition, assures the steady-state of living systems. He enlightens us about the organic and inorganic components of an ecosystem. Consequently, he mentions about the biosphere, which is the largest ecosystem on earth. He informs that the biosphere is the major supplier of renewable and non-renewable resources, which are developed during the process of energy exchange. He explains that while earth and biosphere are closed material systems; the other earthly systems are open systems, including built works of the human ecosystem. Like the ecosystem ecologist Eugene Odum, Yeang also believes in the unlikelihood of a clear distinction between the man-made and natural systems. They are interdependent; what happens in the former affects the latter. As he maintains the equilibrium view of the post-war era, it is not surprising that he stresses upon the spaceship ethic of that period. He puts that the building should be managed to enable its energy and material flow like the one of a spaceship. "In many respects, the problems of survival in an isolated man-made micro-life-support system (as in a spacecraft) resemble the problems encountered in

[60] Yeang, 1995, p. 62.
[61] Yeang, 1995, pp 1-43.

humans' continued survival in the "global life-support system" or the biosphere", he writes.[62]

Yeang continues to inform us on the aspects of built environment that display the ecosystem behavior.[63] He puts that the built environment is composed of biotic and abiotic components, physical actions and operational functions. Therefore not only physical entities, but also social interactions are what make up the building system. From this statement, it can be understood that Yeang conforms with the 60s systems architects that conceive the building not only as a single object, but also part of an entity related with the larger physical and the social context. However, as will be argued in the later paragraphs, contrary of his quest for contextual interaction, he designs his bioclimatic skyscrapers in such a way that they can metabolically operate on any geography regardless of the social and environmental situation. Indeed, as it was mentioned in the third chapter, 60s systems architects were also trapped in their wishes and their realizations; they arranged their buildings as independent entities despite that they assumed as being interrelated ones.

Accordingly, like his 60s predecessors, Yeang divided the process of building into sub-processes.[64] According to him, there are four types of sub-processes. The production and construction processes comprise the first two categories. Then comes the "operational" process, which is the category concerned with the activities of controlling the functioning of an architectural system with regard to the objectives for which it is designed. The feedback control is a significant canon of systems research and analysis, and operations research is used to fulfill that requirement. Yeang believes that the architect should assure the stability of the built environment through the management of the input and output energies. He conforms to the functionalist canon of the 60s systems approach with his preference for the use of the term "operation" in his discourse. According to the functionalist model, every material element was supposed to serve a special function to enhance the integrity of

[62] Yeang, 1995, p. 61.
[63] Yeang, 1995, pp 43-73.
[64] Yeang, 1995, pp 73-89.

the building system. Yeang conceives the management and control as extremely important in the assurance of efficient functioning. According to him, the built environment is supposed to be controlled through its “operational systems”, which are the apparatuses for the control of the functioning of an architectural system with regard to the objectives for which it is designed. As it was mentioned in the third chapter, in the 60s, the operational systems were the ones that provided the human comfort objectives, while today they provide environmental control.

The fourth process defined by Yeang is the recovery process, which indicates the practice of controlling the removal, demolition, renewal, recycling, reuse and regeneration of building materials. Regarding the subject-matter, Yeang writes the following: “Although, in principle, most materials used in building could be recovered, complete regeneration of all components cannot be achieved without an additional expenditure and materials”[65]. He is aware of the fact that having enough knowledge on “nature’s economy” does not indicate that it can entirely be applied in the realm of architecture. Human systems cannot totally contribute to the cyclic processes of nature. Therefore, “the design task should not be directed totally toward a static equilibrium state in which everything is recirculated and used”, he writes.[66] His equilibrium perspective diverts from that of Odum’s in one aspect, that according to him stability does not depend on keeping human ecosystems as closed as possible. In spite of the fact that the ecologically informed architects may help to reduce the burden on nature, their achievements have only a slight effect on the larger environmental context. In fact, according to Yeang, what needed is a transformation in the everyday practices of humanity in general, beginning from the consumption patterns.

According to Yeang, analogizing the building system with an ecosystem brings forward the acceptance of the holistic connections of the building with the rest of its ecological environment. The buildings should conform to the steady-state ecosystems with their metabolic functioning. He has some technical

[65] Yeang, 1995, p. 125.
[66] Yeang, 1995, p. 134.

recommendations on how architects may be involved in developing a homeostatic environment.[67] The first recommendation is about the method of site planning. According to him, the most significant one is being aware of the carrying capacity of the area in which the building is situated. For that, the renewable and non-renewable resources should be specified. Yeang suggests applying the "layer-cake" model of specification developed by the landscape architect Ian McHarg in this respect.[68] Here, the ecology of the site is considered as being consisted of climatic, geographic, hydrologic, biotic and abiotic layers. The resources are identified by categorizing the site into these layers. The site analysis process is to be realized by designating the area layer by layer. Yeang recommends the "sieve-mapping" method of analysis, which is again developed by McHarg, after pondering on the "layer-cake" model. In the "sieve-mapping" method, the layers are projected into the geographical map of the site by means of drawing legends. The interactions between the layers are analyzed by juxtaposition of each map over a light table.

McHarg's twofold method is useful to indicate the area that is most suitable for human intrusion. Through these methods, the designer can be informed about the effects of intrusions before they take place and make his/her best to render these interferences as less entropic as possible. Yeang puts that every area has its own physical characteristics; therefore, the results obtained after juxtaposition may vary from site to site. As information, McHarg developed the method after being involved with an experiment pursued by the architect Louis I. Kahn. The experiment was about finding out "how an astronaut may be sent to the moon with the least possible baggage to sustain him".[69] Indeed, sieve-mapping is one of the means of achieving the similar top-down experience. After this investigation, McHarg concluded that a top-down experience of earth that is made possible through space traveling renders anyone be aware of intense destruction upon natural ecosystems.

[67] Yeang, 1995, pp. 89-117.
[68] Yeang, 1995, pp. 92-96.
[69] Ian McHarg, 1971, *Design with Nature*. New York: Natural History Press, p. 44.

Yeang continues with his recommendations for developing a homeostatic building system after a 'careful site planning' one. The second step is feedback management and control of the building system. Indeed, throughout the book, Yeang persistently mentions about the impact of management for conceiving holistic aspects of life. According to him, the designer architect should consider the energy flows, the physical materials and their interactions and human activities in the system. Thus, the first step towards management is calculating the input and output energy around the built environment. The calculation helps to utilize energy flow in the most efficient way. The expelled and excess energies can be recycled in another context. Yeang recommends applying the method entitled "energetics" that is used to convert mass into energy in that respect. According to Yeang, the calculation of energies helps to estimate both the 'resilience' of buildings against outside natural forces, and the maximum means of material recycle after the building completes its period of use. He suggests obtaining help from computer software in determining the energy inputs and outputs of building systems. Computer censoring will help for the efficient energy management as it displays the percentage of useful energy expelled via the ineffective one.

As mentioned in the previous chapter, owing to the influence of modern economic structure, the culture of management has a substantial place in ecosystem thinking. As put by the historian Donald Worster, management ethic indicates "that neither man nor nature can long survive without direction and control by trained managers".[70] Yeang advices architects to follow ecologists in order to take the responsibility for nature's survival. According to him, they should "engineer" the building in such a way that both the need for mechanical means of support is reduced to minimum during its use and the materials can be utilized in another context after the building completes its period. As a result, in the book *Designing with Nature,* Yeang highlights the most efficient means of material and energy transformation in the built ecosystem, while being aware of the impossibility of total energy-recycle.

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[70] Donald Worster, 1995, *Nature's Economy: The History of Ecological Ideas,* Oxford: Oxford University Press, p. 284.

Consequently, in the book *The Green Skyscraper*, Yeang briefly discusses on the ways to put systems principles into practice by analyzing skyscraper as a building system[71]. Among the building processes of design and construction, he mainly focuses on the "operational" process, which indicates the activity of controlling the ways in which an architectural system functions with regard to the objectives for which it is designed. According to him, the objective for an ecological skyscraper should be maintaining human comfort conditions as negentropic as possible. Therefore, the operational process should be managed by passive systems, rather than the mechanical ones. The climatic considerations of the region in which the building is situated should be considered before the recourse to mechanical implantation. Yeang has some technical recommendations regarding the ecological means of designing the operational systems of skyscrapers.[72] The first technical principle is about the arrangement of plan by taking account of aspect ratios for maximum sunlight capturing. The aspect ratio is the ratio of the vertical (y) with the horizontal (x) edges of the plan geometry. According to that, climatic zones of the lower latitude require an elongated geometry, whereas the higher latitudes require an equal-sided geometry. The skyscraper takes shape through the extrusion of the determined geometry into z direction. (Fig. 4.21).

The second recommendation is about the placement of the service cores of the skyscraper. The cores are placed in the building according to the required heat gain or loss. Obviously, while heat loss is required in a tropical climate, heat gain is needed for a cold climate. The core is placed along the edges of the plan geometry in a skyscraper of a tropical zone, while it is placed at the center in the one of a cool climate (Fig. 4.22).

[71] Ken Yeang, 1999, *The Green Skyscraper*, Prestel: Munich, London and New York.

[72] Yeang, 1999, pp. 197-279.

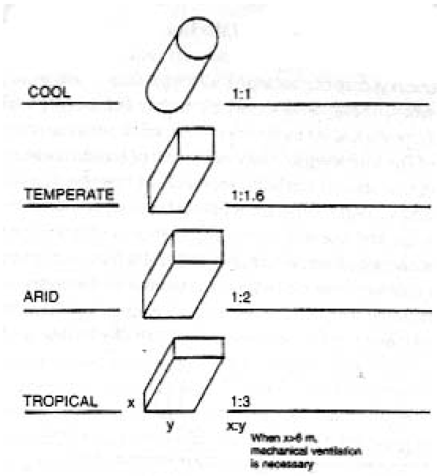

Fig. 4.21. Optimum aspect ratios of buildings.
Source: Ken Yeang, 1999, *The Green Skyscraper*, Prestel: Munich, London and New York, p. 205.

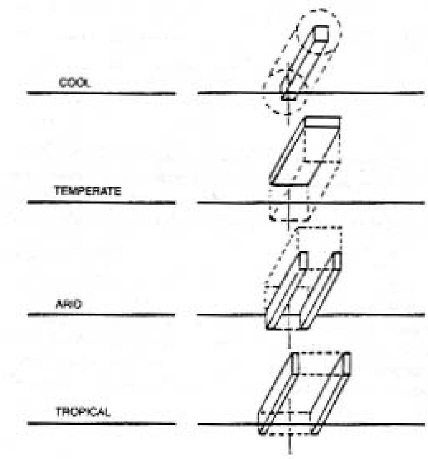

Fig. 4.22. Placement of building cores in a skyscraper according to climates.
Source: Ken Yeang, 1999, *The Green Skyscraper*, Prestel: Munich, London and New York, p. 206.

The third one is about the placement of solar shading devices with regard to climatic zones. The devices such as fixed overhangs, louvers and movable blinds are placed in various angles in winter and summer periods and different climates. Furthermore, Yeang explains that there are passive daylight devices such as light shelves and light pipes. Their placement at the façade also determines the degree of daylight penetration to the interiors (Fig. 4.23).

The fourth principle is about the vegetation of transitional spaces, such as, verandahs, porches, terraces and atrium in the building. According to Yeang, the plantation of transition spaces increases the oxygen gain of the interiors and reduces intense heat in hot climates. The fifth principle is about the conservation of water through recycling systems. He informs that conservation requires the utilization of water that is lower in quality than the drinking water, such as, rainwater or reclaimed grey water. The sixth recommendation is about the usage of biological sources for purifying water and recycling waste. For instance, wetlands and mashes are good resources for filtering grey water. He recommends to process waste by water ecosystems as it is achieved by Nancy and Jack Todd in their bioshelters. The last principle is about the use of non-renewable sources for energy generation. He informs on the latest developments in energy generators, such as, wind turbines, photovoltaics and hydraulics.

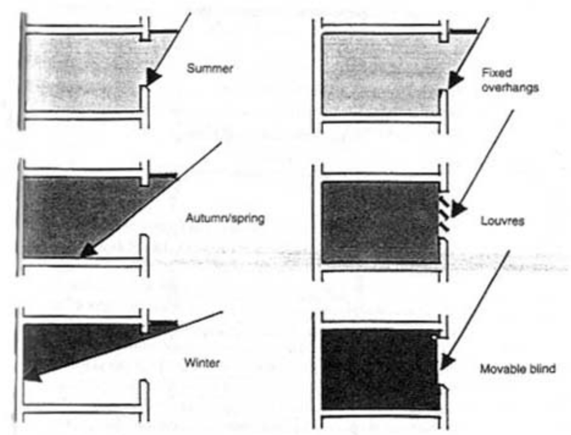

Fig. 4.23. The placement of solar shading devices.
Source: Source: Ken Yeang, 1999, *The Green Skyscraper*, Prestel: Munich, London and New York, p. 224.

Current environmental problems compel anyone holding a career to be skilled in diverse branches in order to make an overall assessment of what has to be done in order to lessen the burden on nature. Yeang concludes his book entitled *The Green Skyscraper*, with the assertion that skyscraper buildings entirely project the necessity of considering "every aspect of the built environment, including its physical, economic, cultural and other roles, in terms of the structure's relationship to the environment" in architecture.[73] However, considering diverse fields of inquiry in design necessitates collaboration with different professionals, meaning a considerable increase in the cost of buildings. As mentioned in the previous chapter, ecosystem scientists faced similar troubles in financing their interdisciplinary projects. Indeed, they were successful in finding investment due to public interest in the earlier years of postwar development. However, their success in persuading supporters continued until the 80s, and after that they were forced to leave the scientific platform to evolutionary ecologists. The current rise of Yeang's ecological skyscrapers all around the world shows that until now, Yeang is skillful in persuading investors as well. He outlines his methods of conviction in the architectural context as the following:

> I have three types of clients: The first comes to me and wants a green building, so there is no problem. The second I get because I won the competition, and in that case they are obligated to build what I have designed. The third is the commercially driven client, which I am afraid represents 80 percent of my clientele. The problem with most architects is that when they get a project, they run off and start designing. In our case, we really don't design until we have a detailed brief and have agreed on the budget with the client. We then design to this budget. When we present a project, we say, "We met your budget requirements. Here are the costs to prove it." Then it is much easier to get the green aspects accepted.[74]

As mentioned in the previous chapter, the need for interdisciplinary expertise comes from the holistic dimension of ecosystem theory. Ecosystem scientists showed their interest in holism by searching interrelatedness in every aspect concerned with ecological research. They put emphasis on the disciplinary network, while studying

[73] Yeang, 1999, p. 63.
[74] Interview with Ken Yeang by Nina Rappoport, in David Gisssen (ed.), 2002, p.177.

energy and material interrelations. Consequently, Ken Yeang also seems to be interested in every means of transmission "across the boundaries of space", in the words of ecologist Evelyn Hutchinson [75]. In an interview, he asserts that his interest in skyscraper is due to its power of integrating flows coming from both the natural and the man-made agenda in a single volume. "An ecologist sees an ecosystem in terms of flows, and we are trying to look at buildings in the same way", [76] he said. Therefore, he tries to put together "energy, water, sewage, materials, vegetation and people" into a single structure.[77]

One of Yeang's recent works, EDITT Tower is an edifice bringing together both natural and human systems into a single structure.[78] It is a skyscraper designed for the tropical climate of Singapore. The building site is selected among those that have already been used for construction purposes, in order to avert further damaging of natural areas. The skyscraper is composed of office spaces with a considerable amount of vegetated areas with plants protruding out of open terraces. Yeang is keen on developing his engineering skills in order to employ as much passive systems as possible in his buildings, and vegetation is one of the means to help him in this respect. Hence, certain plants were chosen for their enhancement of building's passive aspects, besides their visual quality. For instance, they filter rainwater, compost sewage, absorb toxic gases and reduce inside heat by cooling the air. Besides the vegetal implant, certain devices operating with renewable energy were established for water recycle and sewage purification, helping to reduce water use.

Yeang's interest in passive engineering can be observed in his design of fenestration network in the tower. Window openings and light wells are arranged to get maximum benefit from daylight and thus to reduce the need for artificial illumination. The windows can be opened in elevated areas as well, to enable natural ventilation. Moreover, Yeang displays his environmental sensibility by making both

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[75] See Robert McIntosh, *The Background of Ecology*, 1988, 3rd ed., Cambridge: Cambridge University Press, p. 198.
[76] Interview with Ken Yeang by Nina Rappaport, in *Big & Green,* 2002, New York: Princeton Architectural Press, p.177.
[77] Yeang by Rappaport, in Gissen, 2002, p.177.
[78] For details, see Yeang, 2002, p. 108.

construction and future repair and renewal possible without using high amount of energy in the process in order to reduce environmental costs in this respect. For that, he used modular systems in which the material components can be easily demountable and replaceable without damaging the overall frame. Moreover, the building materials were supplied from the locality. Materials are obtained from regional resources in order to lessen the embodied energy impact due to transportation to the construction site. As information, embodied energy indicates energy obtained from non-renewable sources during production, manufacture, transport and construction of materials. Yeang furthers his attempts to lower entropy through his decisions. For that, he oriented the tower to gain quick access to the nearest transportation network and through that he tried to lower the rate of car arrival (Fig. 4.24).

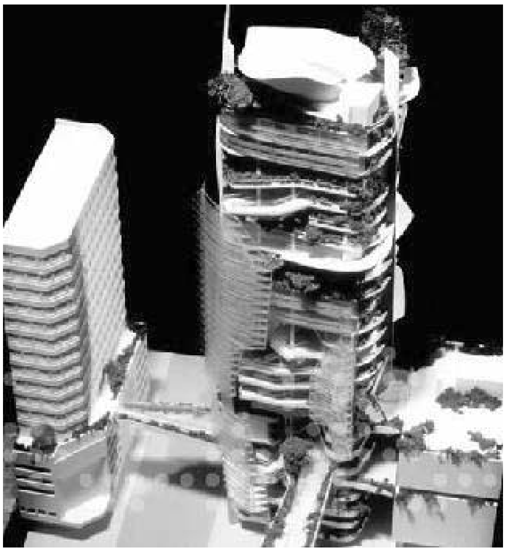

Fig. 4.24. *Ken Yeang,* EDITT Tower, *Singapore, 1998.*
Source: Gissen, David (ed.). 2002. *Big and Green: Toward Sustainable Architecture in the 21st Century.* New York: Princeton Architectural Press, p. 108.

Yeang's involvement with the high-rise began in the 90s, after having designed houses in which he sets forth the regionalist values of his native country Malaysia. For instance, he designed the house in Kuala Lumpur for a wealthy family in 1976 by paying attention to the geometrical arrangement dictated by the Feng-Shui tradition[79] (Fig. 4.25). Hence, in the book *Tropical Urban Regionalism*, Yeang wrote on his tendency towards regionalist architecture in the following:

> Regionalist architecture seeks to incorporate in its design the 'spirit' of the place in which it is located. Its intensions are for a contextual architecture which responds self-evidently to the local conditions. It should relate to the deeper sensibilities and tangible realities to a place, rather than relating primarily to international influences and trends. More specifically, the emergent regionalist architecture seeks its architectural significance through relating its built configuration, aesthetics, organization and technical assembly and materials to a certain place and time.[80]

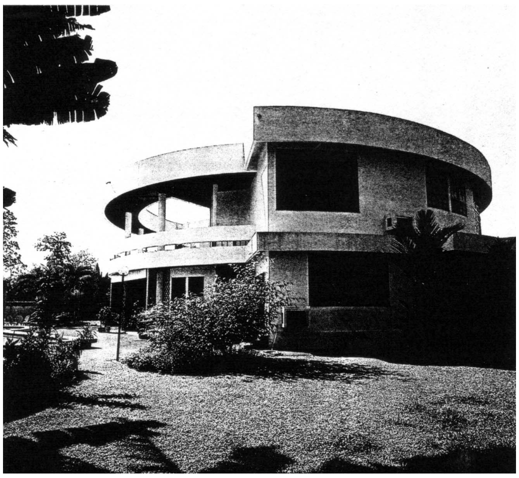

Fig. 4.25. *Ken Yeang,* Ulysees House, *Kuala Lumpur, 1976.*
Source: Robert Powell, 1989, *Ken Yeang: Rethinking the Environmental Filter*, Landmark Books: Singapore, p. 26.

[79] The information on Ken Yeng's early houses are compiled from the following book: Robert Powell, 1989, *Ken Yeang: Rethinking the Environmental Filter*, Landmark Books: Singapore, pp. 22-25.
[80] Ken Yeang, 1987, "Tropical Urban Regionalism", in Charles Jencks and Karl Kropf (eds.), 1997, *Theories and Manifestoes of Contemporary Architecture*, London: Academy Editions, p. 146.

Hence, Yeang projected the cultural spirit of the locality through various vernacular forms of habitation that conforms to the Malaysian tropical climate until the mid 80s. Despite his quest for the Malaysian roots, according to the architectural critic Robert Powell, Yeang's works at that era cannot be considered as entirely regionalist.[81] According to him, it is likely to observe the modernist influences, which is the result of his education and research that he pursued in England and America in the 60s. He wrote for instance, although the Kuala Lumpur house is Feng-Shui oriented, it is not truly regionalist because in some instances, it conforms to the modernist principle of design.[82] For instance, his recourse to pure geometries is the heritage of his modernist-oriented education in the West. Powell emphasized that with its "geometry, circular columns and the roof terrace", the Kuala Lumpur house echoes Le Corbusier's Villa Savoie.[83] His quest for technological efficiency is also another item of Yeang's involvement with modernist canon alongside his playing with pure geometries. Yeang wrote the following in the book *Tropical Urban Regionalism* concerning the subject-matter:

> A particular place would have a physical, social, economic and political status quo besides a cultural and architectural heritage, and natural history. Architecture's function in relating its attributes as a technological product to a particular place and time is a vital connector that links technology with culture. The regionalist design approach seeks to articulate this linkage.[84]

However, Yeang's allusions to the Malaysian vernacular lasted only a decade. Today, he is well-known in the architectural arena mainly for his technologically-implemented bioclimatic skyscrapers that do not refer to a particular style other than modernism. Indeed, Yeang's reference to the locality should not be sought in his projection of vernacular styles in his architecture. It is possible to observe his awareness to the particularities of a certain region not through the vernacular imagery, but through the passive means of dealing with the climatic conditions.

[81] Robert Powell, 1989, pp. 17-21.
[82] Robert Powell, 1989, pp. 22-25.
[83] Robert Poweel, 1989, p. 23.
[84] Yeang, 1987, in Charles Jencks and Karl Kropf (eds.), 1997, p. 146.

Hence, concerning regionalism, the significant issue here is the functionalist attributes of his projects, rather then the artistic ones. Yeang himself mentions about his disdain from a particular aesthetic in the following statement in *Tropical Urban Regionalism*: "What is needed is a holistic concept that can permit the building enclosure itself to be perceived systematically without a prior fixation to a particular aesthetic."[85] He maintains to refer to the Modernist principle of pure geometric arrangement in the skyscrapers. That may be because of his need for a uniform expressive basis in order to focus on the climatic considerations. Indeed, his colleague Kisho Kurokawa indicates this issue in the preface of the book edited by Robert Powell. Here, Kurokawa puts that Yeang's arrangement of transitional spaces in his buildings, such as verandas, porches and atriums projects his South-East Asian roots in its constructing interrelations of the inside with the outside. In the book *Philosophy of Symbiosis,* Kurakawa wrote that the Asian cultural thinking is opposed to the architectural idea of separating spaces through elements such as walls.[86] It is rather on the side of the idea of providing intermediary spaces through transitional elements like atriums and verandas. This is because of the cultural positioning against every form of dualities that evades interrelations. In this sense, one may argue that Yeang's use of transitional spaces have not only an ecological, but also regional standpoint.

However, Yeang's interest in the management ethics and technological know-how reveals his affinity with rationalist form of thinking even though he welcomes arcadian allusions in his architecture. In his books, he mentions about conserving regional values and reviving holistic connections with nature, while claiming computerized control for ecological efficiency. His work is the evidence of the amalgamation of technicist and regionalist paradigms in the current ecological discourse, which is the situation different from the systems architects of the 60s, who support a coherent perspective. As put forward in the second chapter, those who set forth the systems approach in those years prefer to be involved with either the

[85] Yeang, 1987, in Charles Jencks and Karl Kropf (eds.), 1997, p. 147.
[86] Kisho Kurokawa, 1992, *From Metabolism to Symbiosis,* London: Academy Editions, p. 14.

technological advancement or with the enhancement of social relations. However, the combination of both paradigms was introduced by the ecosystem ecology in the post-war era. As mentioned in the second chapter, both paradigms are “mixed in a confusing degree”, in that era, in Donald Worster’s words. In this sense, technicist architects seem to follow the ecosystem ecologist canon five decades after the situation emerged.

Ecosystem science envisioned biological systems in which self-regulatory processes operate like a machine, while Yeang envisioned his buildings operate like a biological system with the aid of technology. He in a way replicates self-regulatory methods of ecosystems in his buildings. Technology not only helps in the efficient working of building ecosystem, but also in the repair and renewal of world ecosystems. Hence, his skyscrapers will pave the way for planetary stability.

4.2. The Reactionary Impulses against the Technicist Bias in the Contemporary Green Architecture

As mentioned in the previous chapter, the rationalist viewpoint was dominant in the systems architecture of the 60s, which considered the human survival in a technologically-driven future. This rationalist bias was contested by the social activists and the arcadians who claimed a return to the past values and an enhancement of the communication between social actors. Accordingly, the contemporary green architecture, which is based upon the systems approach of the 60s, is haunted by the dominancy of the technicist paradigms and the counter arguments, which claim that environmentally-conscious design should project the patterns of social communications, rather those of science and technology.

In this section, it will be argued that the rationalist bias in today’s green discourse is encountered with a reaction that resembles the one displayed by the 60s social activists. This section will put forward that the contemporary reactionary architecture projects the same methods of response with the ones of the 60s, which are the vernacular means of construction, the self-built activities, and the participatory design achievements. Furthermore, it will be argued that the contemporary reactions are developed with a philosophical background provided by the systems approach.

4.2.1. The Green Vernacular

As it was seen in the third chapter, the discourse on the vernacular introduces us to two different dichotomies. The former dichotomy is about the identification of a vernacular artifact; whether with regard to its integral configuration or with regard to the social setting that paves way to its production. The latter dichotomy is about the social pattern of behavior that conditions the vernacular production; whether an individual endeavor or a communal impulse. The theoretician Victor Papanek, who sets forth six explanations to identify a vernacular, points out that there is a general consensus among those who involved with the subject-matter concerning the fact that vernacular is the emblem of the communitarian means of architectural development, therefore should be understood with regard to the social setting it belongs to.[87]

The resulting consensus on the vernacular is indeed conform to the general perspective that was offered, however never realized in the systems approach of the 60s; that is evaluating a particular phenomenon with regard to the context in which the phenomenon takes place. The systems architect Barry Russell announces the fact that when the systems principles were of concern in architecture, the technological configuration of hardware systems attracted more attention, rather then the social setting.[88] In this sense, as the green theoretician Farmer puts, the interest to the vernacular forms in the 60s emerged as a reaction towards the result of such

[87] Victor Papanek, 1995, *The Green Imperative,* London: Thames and Hudson, p.134.

[88] Barry Russell, 1981, *Building Systems, Industrialization and Architecture,* London: John Wiley & Sons, p. 692.

ignorance towards communal values in architecture.[89] He mentions that the ignorance has a historical background dating back to modernism, in which regional values and indigenous techniques are censured in favor of the industrialized mode of production.

Today, vernacular methods of construction are considered in the environmentally-sensitive architectural practice as an appropriate means of using the natural and man-made resources. This idea is announced by the green architects Brenda and Robert Vale, who argue in their book, that vernacular construction is a sample for green architecture for their being the most sustainable use of resources.[90] Vernacular architecture is well-known for its use of local materials or the materials supplied from the nearby environment. That situation reduces the total embodied energy spent during construction. Moreover, the siting and orientation of vernacular buildings conform to the local topographic and weather conditions. The proper orientation enables to handle the ventilation inside the building by passive means, rather than through recourse to mechanical equipment. That situation intensively reduces both the consumption of energy sources and the pumping out useless energy to environment during the maintenance process. Furthermore, Brenda and Robert Vale puts that vernacular architecture is also considered as a means to divert architecture from aesthetic considerations in favor of environmental considerations. According to them, more than aesthetics; the most important issue is the ethics of making the building. The efficient resource consumption is an environmentally responsive means of producing architecture that precedes expressionist impulses.

In the green architectural discourse, aesthetic endeavors are identified with the individual ego of the architect; therefore, those who are critical to the emphasis put on visual expressionism use the vernacular as a sample for communal ethics. Individualism is criticized for diverting the society from collective practices, as it is thought that this condition is one of the reasons to divert us from nature as well. For

[89] John Farmer, 1999, Green Shift: Changing Attitudes in Architecture to the Natural World, 2nd ed., Oxford: Architectural Press, p.11.
[90] Brenda and Robert Vale, 1991, *Green Architecture: Design for a Sustainable Future*, London: Thames and Hudson.

instance, the architect Christopher Day, in his book entitled *Spirit and Place,* points out that green architecture should be associated with the vernacular means of construction, since it stems from a collective endeavor, rather than out of an individual designer's taste.[91] He condemns the search for individual expressionism among green architects today as he believes that this condition distracts them from one of the main canons of environmentalist thinking; which is living in accordance with the particularities of a region, in which the built form is situated. He follows Norberg Shultz's *Genius Loci* in his thesis, and considers that the apprehension of the local characteristic is the way to reestablish the lost relations with nature, and the phenomenological experience of energy relations in the local atmosphere is one of the means for that.[92] He believes that focusing on individuality may distance one from the awareness of the values of a certain place, which is shaped and shared by a collective agenda at the same time, and may highlight only the artistic merits, which may increase the egocentric impulses diverting oneself from the appreciation of the total picture of things.[93]

However, Suzannah Hagan, in her book entitled *Taking Shape,* puts that it is not possible to divert environmentally-responsive architecture from aesthetic considerations.[94] According to her, visual expressionism may be one of the means to educate the public on environmental subject-matter. She wrote the following:

> …architecture, as the product and the producer of culture, is in a position to persuade. It is highly visible persuasion, the reification of certain social desires, and values, over others. This ideological dimension of the aesthetic, its power to win over and hold, has been ignored, or rejected as suspect, by many of those engaged in environmental design. But as a site for the development and display of a new cooperative contract between built culture and nature, it has a catalyzing role to play.[95]

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[91] Christopher Day, 2002, *Spirit and Place,* Oxford: Architectural Press, pp. 12-13.
[92] Christian Norberg Shulz, 1980, *Genius Loci: Towards a Phenomenology of Architecture*, London: Academy Editions.
[93] Day, 2002, pp. 12-13.
[94] Suzannah. Hagan, 2001, *Taking Shape: A New Contract between Architecture and Nature,* Oxford: Architectural Press, pp. x-xix.
[95] Hagan, 2001, p. xiv.

Hence, Hagan stresses the role of visual expression for public education. Therefore, there remains a question on how to attain an environmentally-responsive visual endeavor in architectural practice. The architect James Wines, in his book entitled *Green Architecture,* puts that contemporary green architects develop their expressionist endeavor by borrowing from the aesthetic style of modernism.[96] However, the ideological outlook of that period is the major contributor of environmental destruction. The modern belief in controlling nature via industrial rationality engendered an exploitative attitude towards the environment. According to him, green architecture should not be represented by a style that was produced in the period in which environmental subject-matter is ignored. He follows the Vale couple and Christopher Day in this respect, and suggests architects to look at the forms of expression of primeval cultures, which attained a more responsive attitude towards nature.

According to Hagan, there is a tendency in green architecture to develop a one-to-one-correspondence between cultural and biological subject-matter, hence vernacular is the representative of the cultural diversity that is analogical to the biological diversity in nature. Cultural diversity is ignored in the architecture of the Modern period; hence Rudofsky's exhibition was held in 1967 to challenge this ignorance. In this sense, cultural diversity as represented in the vernacular forms is the assurance for a stable cultural environment, just like biological diversity is the assurance for a stable ecological environment. Indeed, the idea concerning diversity for stability was put forward by the post-war systems ecologists. It seems to haunt the contemporary green architectural discourse as well. Accordingly, as mentioned in the third chapter, the idea that the continuity of the vernacular patterns as a means for stable cultural development was first put forward by Christopher Alexander from the point of view of the systems thinking. In the book *Notes on the Synthesis of Form,* Alexander argues that vernacular forms are more appropriate than those produced by the

[96] James Wines, 2000, *Green Architecture,* Philip Jodidio (ed.), Köln: Taschen.

modern culture, as they are the outcomes through the centuries of feedback response.[97]

However, it is not possible to sidestep the current social conjuncture that is shaped by the modern patterns of living, in which industrialized mode of production plays a major part. Modernity is an inescapable phenomenon that shapes the current socio-cultural environment today. Then, the question is; how can green architecture stress the importance of cultural diversity in an environment in which modern life standards plays a major role? Green architecture should develop such a way that it should not bypass modern lifestyles while setting forth local values; or bypass the importance of individual expressionism while developing a communal ethic. In this sense, green architecture should attain a both/and position of the aforementioned issues while shaping its cultural environment. According to Suzannah Hagan, the concept of "critical regionalism", which the boundaries were set by the theoretician of architecture Kenneth Frampton, can be one of the means to help environmentally-responsive architects in developing a philosophical background regarding the subject-matter.[98] In the book entitled *Modern Architecture: a Critical History,* Frampton outlines his concept in the following paragraph:

> Critical regionalism has to be understood as a marginal practice, one which, while it is critical of modernization, nonetheless still refuses to abandon the emancipatory and progressive aspects of the modern architectural legacy… In this regard, Critical Regionalism manifests itself as a consciously bounded architecture, one which rather than emphasizing the building as a free-standing object places the stress on the territory to be established by the structure erected on the site… While opposed to the sentimental simulation of local vernacular, Critical Regionalism will, on occasion, insert reinterpreted vernacular elements as disjunctive episodes within the whole... In other words, it will endeavor to cultivate a contemporary place-oriented culture without becoming hermetic, either at the level of formal reference or at the level of technology. [99]

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[97] Christopher Alexander, 1964, *Notes on the Synthesis of Form*, Cambridge and Massachusetts: Harvard University Press.
[98] Hagan, 2001, pp. 121-125.
[99] Kenneth. Frampton, 1992, *Modern Architecture: A Critical History,* 3rd ed., London: Thames and Hudson, p. 327.

In this sense, a building can be considered as the product of Critical Regionalism when it reflects both the physical and the cultural conditions of a local setting while eschewing from abundant display of its technological features. Furthermore, the indigenous means of material configuration is more important in a critically regionalist architectural object, rather than the visual imagery of a particular locality. One of the most significant examples for this type of architectural production is the architect Renzo Piano's Jean Marie Tjibau Cultural Center located in Caledonia.[100] The project is consisted of a cluster of nine buildings arranged in a linear position alongside the sea shore. The architect is inspired by the local dwellings of the New Caledonia region, which are constructed by using leaves. Here, Piano used wood strips instead of leaves as devices of a passive system of ventilation. They enable the slight passage of wind inside the building that flows from the sea level. The buildings are glazed in a convex shape that diverts cool air which is heated inside in conformity with the tropical climate. The chimneys located inside the building carry out the hot and humid air to outside with the help of the convex shape. The sunscreens provide shading when there is an abundant exposure to the sun. The inner skin of the double glazing can be manually controlled. The hot air that is let in through the windows can be cooled in the chimneys.

In the project, Piano united the methods of New Caledonian dwelling making with the modern techniques of ventilation. He did not curb his aesthetic sensibility while searching for environmental appropriateness in his architecture. Therefore, Jen Marie Tjibaou Cultural Center is a sample for the architectural achievement through the conformance of the vernacular principles without eschewing from individual artistic expressionism (Fig. 4.26).

[100] The detailed information on Piano's project can be obtained at Ed Melet, 1999, *Sustainable Architecture,* Rotterdam: NAI Publishers, pp. 112-116.

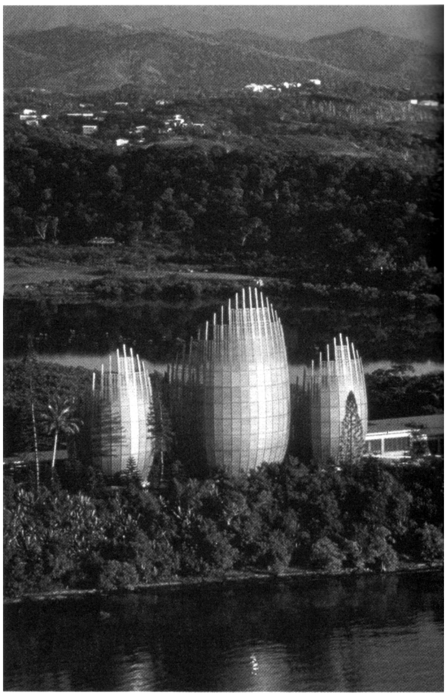

Fig. 4.26. *Renzo Piano,* Jean Marie Tjibaou Cultural Center, *New Caledonia, 1991-1998.*

Source: Ed Melet, 1999, *Sustainable Architecture,* Rotterdam: NAI Publishers, pp. 113.

4.2.2. Self Built and Garbage Housing

As mentioned in the third chapter, the philosopher Harold Morowitz, in his article entitled "Biology of a Cosmological Science" sets forth the alliances of Western thermodynamic science with the Asian religious philosophy.[101] According to him, the central notion of Asian philosophy is that our world is a collection of phenomena shaped with the aid of energy patternings of universe. Likewise, thermodynamic principles also suggest that energy relations shape the earthly incidents. Moreover,

[101] Morowitz, Harold J. "Biology as a Cosmological Science", in J. Baird Callicott and Roger T. Ames (Eds.). 1989. *Nature in Asian Traditions of Thought.* Albany: State University of New York Press, pp.37-51.

Morowitz claims that Asian religious doctrines are influential to modern science especially regarding its ideas on the place of individual in an energy environment. It is believed that an individual in its singularity does not have significance unless he/she is the part of the energy cosmos of the universe. The individual is one of the mediators in the cycles of energy flow, like every living and non-living member; therefore, he/she transiently occupies earth.

Obviously, the Asian philosophy affects everyday living patterns of the Asian societies in general. The Feng-Shui doctrine is the outcome of such influence. As mentioned in the Third Chapter, Feng-Shui assumes that we should place an order to our environment by a particular emphasis on patterns of energy flow, which is believed as having a spiritual character in nature. It was mentioned in the previous paragraphs that Ken Yeang's dwelling projects in the 80s reflect the Feng-Shui doctrine. Accordingly, Kisho Kurokawa, in his book entitled *The Philosophy of Symbiosis,* mentions about the similar conformity with the energy flow patterns in the space arrangement of Japanese dwellings.[102] He informs us that there is not any clear boundary between spaces in Japanese houses in order to enable free flow of energies from one space to another. Therefore, the spaces are separated by permanent division elements, such as translucent sliding doors in order to let free energy flow. Furthermore the spaces are arranged to function in a particular period of time. The idea of transience dominates space configuration as suggested in the Continental philosophies regarding the entropic conditions of our universe. The functions change at an instant in case there is such a requirement. For instance, a tearoom can be converted into a bedroom instantly. Kurokawa puts that such idea of permanence dominates urban life in Japan as well. The urban spaces continuously change in their function with a speed that any inhabitant unable to observe.

Accordingly, while Asian societies conform to the permanent existence by means of transitional spaces, the Western ones were introduced to the issue in the 60s, by means of self-built designs that endure for a short period of time. However, this time,

[102] Kisho Kurokawa, 1992, *From Metabolism to Symbiosis,* London: Academy Editions, p. 18.

transience is not the subject of focus that is related with the conformance to the energy cycles, but with the non-conformance, which resulted in environmental deterioration. This time the anxiety of temporary existence as the result of environmental deterioration is the subject of the underlying discourse, rather than the relief of temporary existence for being in conformity with the earthly energy incidents. Survival instinct triggered those who prefer to endure on earth for a long time. According to John Farmer, the self-built designs of the 60s environmental activists were displaying a survival instinct that manifested with the deteriorating effects of the Second World War.[103] Participatory activities of building without the involvement of an architect set forth the activists' reactions against modern patterns of living that distracted the individual from community relations and thus from nature. Their garbage dwellings in a way displayed the post-apocalyptic age that would force one to live in a deteriorating environment with the materials supplied by hand.

According to Farmer, the historical background of this self built activities dates back to the Romantic movement of the early 19th century, in which the social and environmental corruption brought forward by both the urban patterns of living were first encountered with unrest.[104] Farmer mentions that the wooden cottage built by the writer Henry David Thoreau in the Walden countryside is the result of such an anxiety against corruption. Hence, the contemporary greens that prefer to be involved with such humanitarian missions are also triggered by such uneasiness. In his book *Spirit and Place*, Christopher Day emphasizes that the Asian idea of transience should be the canon for those who revive the vernacular in their displaying of the proper means of habitation on earth.[105] As suggested in the Asian religious doctrines, an individual does not have any significance unless he/she is part of energy relations in the universe. He suggests architects to be part of this philosophy by putting an end to their individual ego and shift their emphasis to the architectural activities that do not ignore the communal patterns of living.

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[103] Farmer, John. 1999. Green Shift: Changing Attitudes in Architecture to the Natural World. 2nd ed. Oxford: Architectural Press p. 149.
[104] Farmer, 1999, p. 149.
[105] Day, 2002, p. 10.

Indeed, the contemporary green architecture is endowed with such activities setting forth human beings' permanent existence on the planet. Such example is the "Earthships" of the architect Mike Reynolds, which are self-sufficient dwellings made of garbage materials such as bottles, car tires and beer cans.[106] The houses are endowed with technological hardware as well as the garbage; the dwellings are heated and cooled by means of the energy supplied from wind generators and photovoltaics. The dwellings are surrounded by tires on three sides arranged in the order of bricks. The tires offer the function of any manufactured insulating material with a minimal capital. The dwellings are preferably built on slopes half buried in the soil to provide natural insulation.

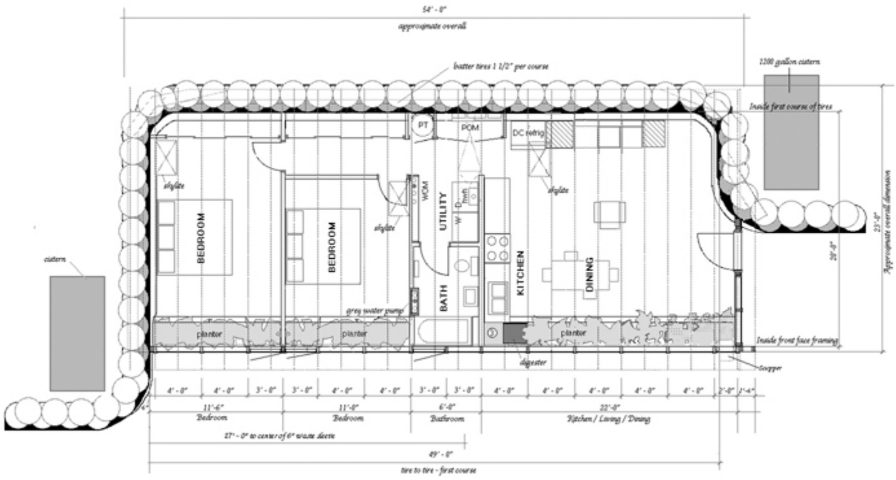

Fig. 4.27. *Mike Reynolds, 1995,* Packaged Earthship, *Plan.*
Source: Mike Reynolds, 1995, "Earthship",
http://www.greenhomebuilding.com/earthship.htm (accessed March 2006).

Especially tire houses are the object of study for Reynolds; who also wrote a book informing on the practical means of developing one's own dwelling out of tires.

[106] The detailed information on the earthships are compiled from the following website: Mike Reynolds, 1995, "Earthship", http://www.greenhomebuilding.com/earthship.htm (accessed Mach 2006).

Reynolds teaches the ones who are interested in the self-built dwellings the energy efficient means of habitation. He believes that his dwellings resemble sailboats that assure its occupiers a safe temporary trip on watery land. The aesthetic concerns are out of the architect's sight as the dwellings are very poor in their expressionist peculiarity. He puts that survival on earth is a more crucial subject for architecture than aesthetic concerns today; as humans are gradually destroying their own sailboat –i.e. the earth. One should display them the efficient means of sailing on their own spaceship earth. As functional requirements exceed the aesthetic ones in a sailboat, this condition is also valid in an earthship dwelling.

Indeed, Reynolds manufactures his dwellings today to display their conformity with the commercial patterns of living alongside the environmentalist ones. According to him, he marketed more than a thousand "earthships" to be constructed in diverse regions of the world. One can observe that green architecture is endowed with such efforts that utilize green issues for commercial concerns. Such case is Kazuo Iwamura's Fukasawa Symbiotic Housing located in the Setagaya ward, Tokyo, Japan. Constructed on a suburban district, the project is comprised of five apartment buildings and a rehabilitation center for the elderly dwellers.[107] Before the site became a housing quarter, it harbored wooden vernacular houses built by the Tokyo Metropolitan Government. The municipality decided to revive this vernacular spirit by rebuilding houses out of the recycled materials of the demolished ones. The project is embellished with every means required for a green development, such as biotopes, wind generators, solar panels etc. Furthermore, the architect took the opinion of the future dwellers that bought the dwellings after a proper marketing strategy before they were built.

A thorough look at the leaflet published by the municipality to explain the green attributes of the project displayed how the architect benefited from the philosophy of symbiosis developed by Kisho Kurokawa. The architect of the aforementioned project aims to unite Japanese vernacular tradition with the modern lifestyles, just as

[107] The information on the Symbiotic Housing is gathered from the following sources: "Environmentally Symbiotic Housing", 2001, http://www.iijnet.or,jp/ibec/ (accessed April 2001).

Kurokawa aims at the symbiosis of tradition with modernity in his architecture. Indeed, the setting forth the word "symbiosis" is no other than the marketing strategy of the municipality to attract elderly population to suburban areas. Today, in Japan, the young generation prefers to dwell in urban lots due to the long working hours. Therefore, urban housing is mostly developed according to the needs of the younger generation. This renders the elderly to encounter difficulties in their life at urban areas. Symbiotic houses are mainly intended for the elderly people to enable their contact with neighbors, live in healthy environments and enjoy nature (Fig. 4.28).

Fig. 4.28. *Kazuo Iwamura,* Fukasawa Symbiotic Housing, *Tokyo, 1997.*
Photograph by the author.

It is not a hidden issue that the green architecture setting forth the green attributes is a novel means of marketing architecture. Hence, Fukosawa Symbiotic Housing is one of the cases of green development having commercial intentions. However, there are some cases in which the activist spirit comes over the commercial one. Such activism was carried out by the Hungarian architect Elemer Zalotay for a dwelling for his own accommodation in Switzerland.[108] The building is made out of industrial garbage, such as aluminum, plastics and glass. A particular amount of garbage is ordered around cable wires and mounted on the façade. According to James Wines, this building is erupted out of natural landscape with an articulation "by a collage choreography that fills the site with a cacophony of anarchic movement".[109] The project is located in an area where wealthy groups live; and thus attracted irritation and disgust. Zalotay's building met some protests and was stoned by the neighbors (Fig. 4.29).

Fig. 4.29. *Elémer Zalotay,* Maison Zalotay, *Ziegelried, Switzerland, 1984.*
Source: Wines, James. 2000. *Green Architecture.* Philip Jodidio (Ed.). Köln: Taschen, p. 205.

Here, garbage housing is the means to protest against the destructive role of humans that curb the long time endurance of our planet. The temporary building is indeed one of the emblems of resistance against human's temporary existence. Impermanence, which is one of the inevitable phenomena of life, brings forward

[108] The information about Zalotay House is obtained from the following book: Wines, James. 2000. *Green Architecture.* Philip Jodidio (Ed.). Köln: Taschen, pp. 208-209.
[109] Wines, 2000, p. 208.

unease as well. The primitiveness brought forward in the self-built may be the prospect for humanity in the post apocalyptic age.

4.2.3. The Decayed Architecture of the Post-Decadence Era

John Farmer, in his book *Green Shift*, mentions about certain Romantic idealizations of the past that were displayed in the architecture of the eighteenth century, which according to him provided a historical basis for the green architecture of today. As he informs us, one of the means to express the longing for primeval values was the depiction of architecture in the decayed condition invaded by plants and insects. According to Farmer, a ruined building was the emblem of giving moral or aesthetic lessons for a degenerating culture corrupted in spirit. Furthermore, a one-day-life in the ruined settlements was depicted by the poets and writers of the era in order to take the reader back to the past. Farmer mentions about Piranesi's paintings in which the ruined Roman arches were depicted in a ruined condition (Fig. 4.30) Accordingly as Farmer informs us, Piranesi's depictions were so influential in that era that architects embellished their projects with ruined arches to enhance the picturesque quality of their architecture. The following statement, which was cited by Farmer from Geoffrey Grigson clearly outlines the Romantic enthusiasm for ruined settlements:

> …a ruinous building does work its healthy function in human feelings and thought, not only because it shows death, but because its death does nourish these lichens and these green algae, does nourish this moss on this thatch, this rose-bay willow-herb on the beams, does give birds places where they can build in the cracking walls, does give crannies to insects, fro the bee to the woodlouse. For us in our disorder, in our muddle of disintegration, a ruin should give special delight, because beyond symbolizing disorder and death, beyond nourishing wilderness, it yet imposes some order on that wildness, some order of the rectangularity of walls, the triangularity of eaves, the parallels of the roof timbers half concealed, half shown.[110]

[110] Farmer, 1999, p. 44.

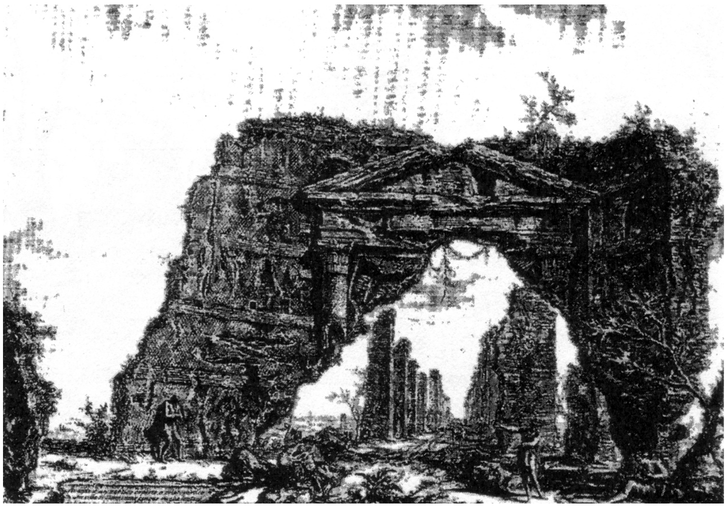

Fig. 4.30. *Piranesi,* Sette Bassi.
Source: Farmer, John. 1999. *Green Shift: Changing Attitudes in Architecture to the Natural World*. 2nd ed. Oxford: Architectural Press, p. 44.

The above statement displays that a ruinous building was the symbol for the two contradictory impulses of life and death. While the invasion of nature on the building was the symbol for the obedience of the humanity to the inevitable phenomenon of degradation, the remnants of the building is the symbol for the resistance to death. This gloomy picture is supposed to resurrect in the post-apocalyptic age, in which every member inevitably returns to primeval forms of living as the result of the depletion of resources alongside the destruction of technological tools that plays a major part for human well-being. Human beings will be left over on a demeaned spaceship with their industrialized system decayed under the ravage of nature. As mentioned in the second chapter, this gloomy outlook was first announced by the post-war systems ecologists, who assumed humans leading to extinction, while our spaceship re-balancing without its human passengers.

Accordingly, the following paragraphs are about the contemporary buildings of decay, being the visual evidences of the recent social corruption that decelerates the negentropic peculiarity of our planet. This depressing outlook is resurrected by those architects who intentionally leave their creations under the rage of nature. Such building of decay is the BEST Company Showroom in Virginia, USA.[111] (Fig. 4.31) Designed in 1980 by SITE architects, it is situated in an existing forest. The trees integrate the building as the architects split the front façade 35 foot from the entire volume. The cleft becomes the outside corridor space for the visitors' approach of the building. The plants help in the entropic degradation as they entirely surround the building. As its creators put it, the design visualizes our post-apocalyptic condition, thus, gives moral lessons to humanity. They utilize decay to put an end to our corruption. James Wines, the member architect of the SITE group wrote the following:

> This building was constructed in a densely wooded suburban area, and sited so as not to destroy existing vegetation. The surrounding forest site invades the structure in such a way that architecture appears consumed by some portentous role reversal- or "nature's revenge". This sense of intrusion by trees and plants is achieved by a massive incision, splitting apart the walls and allowing the heavily forested context to take over. This phenomenon is hyperbolized by the surrounding asphalt, giving the appearance of architecture invaded and consumed by nature.[112]

The SITE group used their architecture as a source of information to transmit their message to the society in general. Indeed, the showroom building has an iconographic value alongside its environmentally-conscious attribute. However, there are some green buildings in which the functional quality exceeds their emblematic character. Such case is the American architect William McDonough's GAP Headquarters in Bruno, California designed in 1996.[113] Here, the entire roof is covered with vegetation to serve functional purposes, such as toxic gas prevention, sound insulation, water absorption etc. The green habitat on the roof structure does not display the revenge of nature against social corruption, but the environmental

[111] The detailed information on the BEST Forest Building can be obtained from the following book: Michael J. Crosbie, 1994, *Green Architecture*, Massachusetts: Rockport Publishers, p. 120.
[112] Wines in Crosbie, 1994, p. 120.
[113] The information about the project is complied from the following websites: Ken Shulman, 2001, "Think Green", http://www.metropolismag.com/html/content_0801/mcd/index_c.html (accessed March 2006); Florence Williams, 2002, "Prophet of a Bloom", http://www.wired.com/wired/archive/10.02/mcdonough.html (accessed March 2006).

quality of the building. According to McDonough, a clay or aluminum mounted roof does not last in longer periods when compared with a "green roof of ancient grasses."[114] He puts that a green roof "saves millions of dollars in storm-water equipment".[115] The roof harbors a plant and animal ecosystem "with native grasses and wildflowers atop 6 in. of soil that both fools the birds and serves as a thermal and acoustical insulator"[116]. As the site is near to an airport, it insulates the excess sound that occurs while the planes take off and land. The building has other green attributes as well. For instance, the floors are raised above the ground to allow air flows and thus create a ventilating effect. Furthermore, the building materials are developed by William McDonough's chemist partner Michael Braungart out of non-toxic equipment. The entire volume is interrupted by large atriums to let daylight penetration.

Today, McDonough is mostly commissioned by the large-scaled industries that rebuild their public reputation from "environmentally inconsiderate" to "environmentally sensitive". Those who are mostly known for their environmentally disruptive practice prefer McDonough to emancipate themselves from public reaction. For a company, a built form is the best means to announce the public about the change in its policy towards the green issues. As discussed in the early paragraphs, architecture "has the power to persuade". Hence, McDonough uses green habitats as both a means for giving message to the public and the means for helping to rebuild the regenerative system of our planet. He resurrects the Romantic longing towards arcadian gardens for enhancing not only the iconographic, but also the environmental quality of green architecture.

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[114] William McDonough in Michael Lewis, "Designing the Future", 2006, http://www.msnbc.msn.com/id/7773650/site/newsweek/, (accessed March 2006).
[115] McDonough in Lewis, 2006.
[116] Ken Shulman, 2001.

Fig. 4.31. SITE, Best Forest Building, Richmond, Virginia, USA, 1980.
Source: Michael J. Crosbie, 1994, *Green Architecture*, Massachusetts: Rockport Publishers, p. 121.

4.2.4. On The Entropic Misfitting

The systems scientist Fritjof Capra, in his book entitled *The Turning Point*, emphasized about the shifting mentality in the discipline of medicine due to the influence of Asian philosophy, which he puts as the basis the systems approach.[117] He puts that the current investigations in the medical sciences display that a person's illness is not only the result of the malfunctioning of bodily parts, but also to the disorderly state of the individual's social and environmental context. The strain and discomfort in one's life has a profound effect on his health. Capra puts that the recent discoveries on the impact on the social and physical environment on one's illness incited scientists to redevelop their investigations by taking the systems approach into account, which puts that the constituents are affected by the total organization in the process of development. He points out that scientists get help from Asian forms of therapy that firstly look at how the person's bodily parts are affected by both the

[117] Fritjof Capra, 1983, *The Turning Point: Science, Society, and the Rising Culture,* New York: Bantam Books, pp. 305-325.

operation of the total body system and the environment. He exemplifies Shamanic and Chinese forms of healing in this respect. He puts that the Shaman transforms himself to "nonordinary state of consciousness in order to make contact with the spirit world on behalf of members of his or her community"[118] to understand how the ill person is affected by his/her social and physical patterns of living. He writes the following:

> The outstanding characteristic of the shamanistic conception of illness is the belief that human beings are integral parts of an ordered system and that all illness is the consequence of some disharmony with the cosmic order. Quite often illness is also interpreted as retribution for some immoral behavior. Accordingly, shamanistic therapies emphasize the restoration of harmony, or balance, within nature, in human relationships, and in relationships with the spirit world.[119]

He continues that the idea concerning the effect of the totality of environment on the physical state of being exists in the Chinese medicine as well. In the Chinese context, the expert diagnoses the illness by analyzing the general operation of the total body system, rather than focusing on the organ itself. Capra writes the following:

> The Chinese idea of the body has always been predominantly functional and concerned with the interrelations of its parts rather than with anatomical accuracy. Accordingly, the Chinese concept of a physical organ refers to a whole functional system, which has to be considered in its totality, along with the relevant parts of the correspondence system. For example, the idea of the lungs includes not only the lungs themselves but the entire respiratory tract, the nose, the skin, and the secretions associated with these organs.[120]

The Asian philosophical outlook, which has a profound impact on the systems approach, influenced current medical investigations that previously put emphasis on the functioning of the organ rather than the entire physical and social system. For instance, he mentions about the recent cancer treatment, which is developed by the radiation oncologist Carl Simonton. The Simonton approach considers cancer not as

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[118] Capra, 1983, p. 308.
[119] Capra, 1983, p. 311.
[120] Capra, 1983, p. 314.

the malicious behavior of a particular cell, rather than a corruption in the homeostatic system of a particular body. Simonton put that cancer is the result of a larger socio-cultural environment that put stress on one's individual life, and the corruption of homeostasis is the outcome of such process. Therefore, the doctors who endow a Simonton approach investigate not only on the behavior of a particular body cell, but on the total bodily system plus the environment that shapes the individual. Capra concludes that understanding of an illness as both a social and a physical phenomenon rendered the scientists to focus more on systems thinking. He wrote:

> Systems thinking is a process thinking, and hence the systems view sees health in terms of an ongoing process. Whereas most definitions, including some proposed recently by holistic practitioners, picture health as a static state of perfect well-being, the systems concept of health implies continual activity and change, reflecting the organism's creative response to environmental challenges. Since a person's condition will always depend importantly on the natural and social environment, there can be no absolute level of health independent of this environment. The continual changes of one's organism in relation to the changing environment will naturally include temporary phases of ill health, and it will often be impossible to draw a sharp line between health and illness.[121]

Hence, the researches being pursed concerning the impact on physical and social phenomena on the healthy state of the individual, which began after the shift in the medical scienes, have a certain impact on the discipline of architecture as well. Architects who focus on environmental subject-matter begin to pay attention to the recent investigations showing how the built environment affects the human well-being. As information, the negative impact of the building to a person is scientifically identified under the concept "The Sick Building Syndrome", which is defined by the Environmental Protection Agency as:

> …situations in which building occupants experience acute health and/or comfort effects that appear to be linked to time spent in a particular building, but where no specific illness and cause can be identified. The complaints may be localized in a particular room or zone, or may be spread throughout the building. [122]

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[121] Capra, 1983, p. 316.
[122] David Gissen, 2002, p. 185.

Environmentally-sensitive architects encounter the "sick building syndrome" with regard to the diverse perspectives. The technicist architects consider the scientific investigations displaying the use of toxic materials on health; the arcadian/primitivist ones put the blame on the modern ways of living affecting the social condition. On the technicist side; we may consider Richard Rogers, who rely on the scientific research and investigation for enhancing the well-being of the individual. In the first part of this chapter, it was mentioned that the architect Richard Rogers uses the materials which their non-toxic quality was approved after experiments pursued by the chemists. Another figure is the architect William McDonough, who set a partnership with the chemist Michael Braungart to render his works non-toxic. McDonough, while enhancing the "arcadian" state of his building by garden implantation, at the same time reinforces its "rationalist" state by getting help from scientific research in this respect.

Accordingly, the architect Christopher Day, who believes that the endowment of a "spirit" to an architectural space takes away the negative pressure on an individual, thus helps in their sustaining of their appropriate means of bodily functioning. In his book entitled *Sprit and Place,* offers certain methods of transforming a particular space to a spiritual place. One of them is the design of spaces to enable their benefiting from the outside air currents. According to him, the decline of air quality of the inside spaces are one of the major causes of unhealthy state of being; therefore he suggests to design the façade with cavities acting as the wind passages that allow air flow. The other method is designing lightwells inside the building to enable sunlight passing though the spaces. Day believes that sunlight penetration helps to develop a healthy place. His last suggestion is about the development of the mental state by enhancing communication between social actors. He believes that social interaction is one of the best means to develop the spirit of the place, which has a profound effect on personal well-being. Therefore, he suggests designing transitional spaces inside and outside the building that may help social interaction. Such spaces as atriums, porches, verandahs, eaves may help in the development of a communicative impulse between the occupants. The clustering of dwellings is also another way to enhance neighborhood interaction.

Indeed, Day's architectural ideas echo Christopher Alexander's theories on vernacular means of spatial design. Hence, Day in a way combined Norberg-Shultz's ideas on place identity with Alexander's theories on vernacular means of space arrangement to develop his green discourse. In this sense, the discourse on health harbors the desire to put an end to the environmentally malicious activities of the humanity, which is subject to corruption and decay, thus, which put a threat to future generations.

4.2.5. The Regionalist Tendencies of Paolo Soleri: Arcosanti in Arizona

After his Arcologies in the 60s, Soleri reinforced his theological conviction through a couple of visionary Arcologies in space that he developed in the 80s. Today, he is known for his realized projects rather than his visions; that his experimental town "Arcosanti" in Phoenix, Arizona, is visited by the people around the world. Built on approximately 800 acres of land, Arcosanti is continuing to be built with the help of the donated capital to the Cosanti foundation. According to Soleri, the town provides an alternative to the urban ills, including sprawl and deterioration. Indeed, it is possible to observe the efforts on the environmentally-conscious urban development in Arcosanti. The low-rise dwellings conform to topography by means of proper siting. Furthermore, a search for energy efficiency can be observed as well; as the spaces are properly oriented for a maximum benefit from the sun. Every dwelling has its own nursery that both enables organic food production and increases the percentage of greenery in the area. The circulation pathways are designed in cross-sections to enhance social communication and neighborhood relations. Walking is encouraged through both preventing car access to the area and enabling pedestrian reach to every destination (Fig. 4.32).

Despite its aforementioned environmentally-sound properties, Arcosanti conforms to none of the principles of ecological urbanism that was previously put forward by Soleri. First of all, his low-rise dwellings have nothing to do with his large-scaled vertical solutions that were entirely visualized in his Arcologies. Secondly, they do not correspond to his principle of "miniaturization", that assumes the compact form for the efficient energy cycle. The reinforced concrete dwellings are dispersed in the area, rather than being in a denser pattern of development. Thirdly, it is not possible to observe any means of technological innovation, which Soleri considers as essential for sustaining the homeostatic system in an urban structure. Frankly, the dwellings seem to be part of formal experimentation, rather of the technological models of living. His familiarity with the ceramics industry might be the reason for his experimenting with reinforced concrete. Hence, Soleri's ceramic potteries and windbells are one of the incomes of the Cosanti foundation today; that they are sold as a souvenir to those who visit the site. Indeed, Soleri seem to serve his knowledge on the ecological subject-matter for the purpose of rendering Arcosanti a place of tourist attraction.

Fig. 4.32. *Paolo Soleri,* Pumpkin Apse and Barrel, Arcosanti, *1967-70.*
Source: Paolo Soleri, 1969, *The City in the Image of Man,* Massacchussets: The MIT Press.

4.2.6. Neo-Organic Reflections of the Disequilibrium Perspective to Architecture

As argued in the second chapter, it was understood that the systems ecology underwent a paradigm shift through the effect of the developments in evolutionary science in the 80s. The systems scientists who are interested in evolutionary ecology found out that not only equilibrium, but also disequilibrium is a condition among the members of an ecological system in the process of energy exchange. A living system may undergo transformation of its state due to exceeding the threshold conditions that ensures the stability of the system, which may not lead to death and extinction as a result. The transformation process might be the consequence of an individual behavior of a species as well as the entire ecosystem. Hence, an individual entity might trigger the formation of a novel means of growth and development. Therefore, a communal impulse is not a precondition for ecological sustainability. In the second chapter, we have seen how this idea set up new hypotheses especially in biological engineering. One of them is that the integration of any new mechanical or biological intrusion to a system, which threatens its stability, may lead to the development of new stabilities.

As mentioned in the Introduction Chapter of the thesis, the geographer David Harvey criticizes the abundant use of the term sustainability in the socio-economic studies for the maintenance of an individual status quo, rather than the environmental one.[123] He writes: "What is then evident is that all debate about ecoscarcity, natural limits, overpopulation, and sustainability is a debate about the preservation of a particular social order rather than a debate about the preservation of nature *per se*."[124] The recent scientific discovery tells that the sustenance of status quo is not always beneficiary for the entire ecosystem; therefore, the idea that it is a necessary phenomenon for environmental sustainability is scientifically disputed. It is found

[123] David Harvey, 1997, *Justice, Nature and the Geography of Difference,* 2nd ed. Oxford and Massachusetts: Blackwell Publishers, p. 148.
[124] Harvey, 1997, p. 148.

out that long time endurance is dependent on the regular repetitions of fluctuations in short intervals. In the third chapter, it is outlined that individual species has a role in not only triggering of the fluctuation in an ecosystem, but also informing other members on the knowledge of survival in case of such a fluctuation. The maintenance in the knowledge sharing is the assurance of the endurance on the planet earth.

Then the question that may be asked is about the correspondence of this paradigm shift in the architectural realm. The disequilibrium picture drives architects, who are interested in environmental issues, towards formal experimentation in their built works. The discovery of the role of individual behavior in the setting up of evolutionary existence resulted in the initiation of individual expression in green architecture. Here, architects focus on informing the public about environmental safeguarding through the use of their expressive impulse. In this way, they get the opportunity to conform to one of the assumptions of systems ecology regarding the conservation of knowledge in the formal structure, which is discussed in the third chapter. Here, the built form becomes a transmitter of knowledge on human survival. Artistic ingenuity is the indicator of cultural development, which is the means towards environmental protection.

Accordingly, one of the figures who associate disequilibrium view with formal ingenuity is the American architect Eugene Tsui. In his book *Evolutionary Architecture,* Tsui explains how he expresses his individual endeavor by adapting natural forms to his architecture.[125] He believes that the contemporary green trials reflect the ignorance of architects towards aesthetic issues. According to him, a green built form should give visual delight as well as functional satisfaction. Tsui believes that the reconsideration of the organic tradition in architecture with regard to the recent scientific and technological developments is the means towards the reflection of the disequilibrium picture. Hence, his suggestion for the disequilibrium architecture is the technological implantation to the organic forms.

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[125] Eugene Tsui, 1999, *Evolutionary Architecture: Nature as a Basis for Design,* New York: John Wiley and Sons.

As mentioned in the Introduction Chapter of this thesis, the architect James Wines argues that the machine age optimism is always sustained in contemporary green architecture.[126] It seems that with the help of bio-engineering, this modernist canon is replaced by another ideal in architecture today, which is, the ecological reconstruction of nature by means of technological expertise. The theoretician of architecture Mark Dery, in his article appeared in the book entitled *Eco-Tech,* emphasizes that contemporary architecture replaced "the hallmark of industrial age" with "the hallmark of neo-biological civilization", which "returns the designs of its creations toward the organic again".[127] The shift from ideas of mechanically-repaired to biologically-engineered planet opened up the possibility for not only ecological reconstruction of natural environment, but also that of man-made organizations, which buildings are one of their products. Hence, Dovey informs us that "house-body homology", which according to him is one of the issues making up of the arcadian vision of architecture, will not forever stay in the realm of the metaphoric.[128] He cites the words of scientists Yoshihito Osada and Simon B. Ross-Murphy, saying "We believe that in the not too-distant future, we will find a way to build 'soft' machines that can respond in intelligent fashion to their environments".[129] It seems that architects will contribute to this futuristic dream by developing "living buildings conjured out of thin air by teeming, unseen nanomachines"[130] in the upcoming epoch.

Eugene Tsui's identification of the contemporary organicism reinforces the idea that the term has undergone a paradigm shift in parallel with the shift in biological sciences. Accordingly, he puts that organicism today is not understood as the conformance of form to function that is dictated by a certain environment for the

[126] Wines, 2000, p.11.
[127] Here, Mark Dery quotes Kevin Kelly, which argues about the implications of cultural shift from industrial civilization to that of "neo-biological civilization", in his book entitled *Out of Control.* See Kevin Kelly in Mark Dery, 1999, "The Persistence of Industrial Memory", in *Eco-Tec: Architecture of the In-Between,* Amerigo Marras (ed.), New York: Princeton Architectural Press, p. 59.
[128] Dery in Marras, p. 64
[129] Dery in Marras, p. 64
[130] Dery in Marras, p. 63.

assurance of its stability. Rather, organicism is considered as the degree of a certain form of adaptation to the fluctuations that threaten the steady-state functioning of the environment. “Resultant forms depend entirely on varying rates of growth, which determine the outcome of the structure”, he writes, and continues: “A natural object grows along the lines of greatest stress. It is really the pathways of stress and strain that give an object its fundamental characteristics.”[131]

According to Tsui, architects should imitate the trial and error process of living entities in their way towards adaptation to their environment.[132] The outcome of this trial and error process in the nature is diverse shapes which are non-identical with each other. Likewise, formal experimentation in architecture engenders the development of new organic structures. Tsui believes that the diversity of formal combinations in architecture resembles the biodiversity in nature. Indeed, biodiversity is always necessary for both equilibrium and disequilibrium environment. Furthermore, Tsui exemplifies certain forms that are found in nature, which develops during their adaptation process in the fluctuating environment. One is the termite nest, which has a conical shape with ventilation shafts intuitively created by termites. The airwells enable air currents inside the nest, such that it is passively ventilated. The other is the beaver nest, which is erected in watery areas, especially alongside riverbeds by taking the water flow patterns into account. The nest has various functional qualities like acoustic insulation or passive ventilation, which is also intuitively set by beavers. Tsui puts that architects should take into account the functional attributes alongside the formal structure in their buildings, like it is considered in nature, to render their built forms environmentally-appropriate. Hence, in the later sections of his book, Tsui gives examples from his own architectural projects, which he develops by imitating nature (Fig. 4.33). A close inspection of the projects reveals that they are devoid of functional attributes that are needed for ecological efficiency. His own “termite nests” does not function like the termite nest except the resemblance. Indeed, it seems that he favors benefiting from

[131] Tsui, 1999, p. 29.
[132] Tsui, 1999, p. 21.

the analogical canon of architecture, rather than the ecological functioning of nature for his buildings.

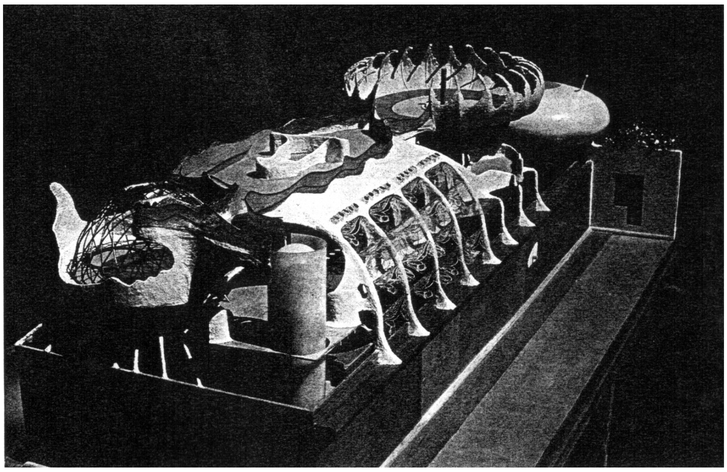

Fig. 4.33. Eugene Tsui, *Tsui Design and Research, Inc. Headquarters,* 1991-1996. Source: Eugene Tsui, 1999, *Evolutionary Architecture: Nature as a Basis for Design,* New York: John Wiley and Sons, p. 150.

Likewise, the English architect John Frazer's interest in morphologies, which are displayed in his book that has the identical title with the one of Eugene Tsui, is the evidence that the disequilibrium science triggers the endeavor of architects towards formal experimentation.[133] He puts that his research on form is the result of his holistic approach, which according to him should be the basis for the ecological architecture as well. Hence, he abundantly benefits from the terminology of biological sciences, to explain his ideas about the form generating process in architecture:

> An evolutionary architecture will exhibit metabolism. It will enjoy a thermodynamically open relationship with the environment in both a metabolic and a socio-economic sense. It will maintain stability with the environment by negative feedback interactions and promote evolution in its employment of positive feedback. It will conserve information while using

[133] John Frazer, 1995, *An Evolutionary Architecture,* London: Architectural Association Publications.

> the process of autopoiesis, autocatalysis and emergent behavior to generate new forms and structures. It will be involved with readjusting points of disjuncture in the socio-economic system by the operation of positive feedback. This will result in significant technological advances in our ability to intervene in the environment. Not a static picture of being, but a dynamic picture of becoming and unfolding- a direct analogy with a description of the natural world.[134]

In some parts of the book, Frazer displays how the "closest packing of spheres", which are the geometric forms discovered by Buckminster Fuller, are transformed into non-identical asymmetric forms, as the result of the integration of diverse geometries, which does not belong to the triangular family with the one of the closest packings. The introduction of irrelevant geometries to a symmetrical structure triggers the evolution of diverse morphologies out of this symmetry, which, can be a point of departure for investigations concerning the relationship between built forms of pure geometry with the physical site that has an uneven geometry. Frazer gets help from computer software in his form generating experiments, which, according to him, heralds the advent of systems approach to architecture. A reminder can be put here that the architect Nicholas Grimshaw's Eden Project is the result of such an investigation. Basically, Grimshaw located his geodesic domes to the roughly structured site with the help of computer software.

In this sense, architects seem to follow the recent developments in equilibrium science to reconsider their green style. Accordingly, the architect and theoretician Charles Jencks, in his book entitled *Architecture of the Jumping Universe,* points out that the environmentally-responsive architects of today widely refer to the organicist approach to set forth their expressionism. Hence, the book entitled *New Organic Architecture* gives us further clues on how the contemporary redefinition of organicism affects green trials in architecture. According to its editor, David Pearson, contemporary organic architecture is a "free-style approach", which takes its philosophical background from the writings of the representatives of the disequilibrium science, such as the systems thinker Fritjof Capra and the systems

[134] Frazer, p. 103.

scientist James Lovelock. Furthermore, Pearson also mentions about the well-known evolutionary ecologist Charles Darwin's doctrines as an inspiring source in architecture, who indirectly contributes to the setting up the new paradigm shift in the systems sciences, which is entirely outlined in the Second Chapter of this thesis. As Pearson puts, there is not a reference to any particular typology while setting up the personal aesthetic style among the contemporary organicists. The lack of any formal reference renders the built entity eccentric in artistic expressionism. They are the emblems of cultural diversity, as analogized in architecture, which takes its philosophical background from the systems sciences, with regard to the biodiversity of nature. Accordingly, the lack of reference does not indicate the releasing of the building from every convention in architecture either. Pearson puts that architects take inspiration from the structural and formal configuration of living organisms, like their predecessors since the seventeenth century.

Pearson adds that social communication systems are not taken for granted while displaying the individual expressionism; that user needs and habits are entirely analyzed by the organic architects to integrate user choices with individual endeavors. In this sense, architects put their desire of individuality under the service of social communication. As mentioned in the second chapter, ecosystem ecologists today analyze on the role of individual with regard to the larger social and environmental context for the maintenance of their system. They found out that the social activities between the members in a cooperative rather than competitive way is determinant for the long term endurance of an ecosystem. Hence, contemporary organicists seem to consider the recent developments in the biological sciences that take account individual endeavors in the wider context of cooperation.

Pearson's examples on the organic approach display that there is not a dominancy of perspectives in the representation of the disequilibrium view. The "free-style" approach renders the freedom of expression in the contemporary organicism. As the wide spectrum of his book suggests, those who prefer being on the side of arcadian revivals embellish their buildings with the zoomorphic paradigms; the tendency of which, according to the theoretician John Farmer, dates back to the Romantic era.

Farmer, in his book entitled *Green Shift,* puts that the nostalgic longing for the past in the Romantic era occasionally resulted in the use of childhood metaphors in architecture, alongside the development of primitive huts or the decayed buildings. He informs us that the nineteenth century architectural culture was widely affected by the biological investigations on the animal population that was initiated by the biologist Charles Darwin, who set forth taxonomy of animal species in order to develop his hypothesis on evolution through natural selection. According to Farmer, the tendency of the 60s architects towards the zoomorphic paradigms might be the reflections of the one that belonged to the Romantic period. He claims that the 60s architect Herb Greene for instance, abundantly used animal metaphors in his architecture. Farmer believes that Greene's Prairie house was developed out of the combination of his organic vision with his childhood impulse. It seems that the Romantic longing for the childhood past set up the roots of contemporary organicism as well. The zoomorphic paradigms help the architects of today in the reconstruction of our survival instinct by taking our past values into account. David Pearson exemplifies the works of Hungarian architect Imre Makovecz, who is one the representatives of the arcadian approach in organicism, which are revealed in his architecture as well as in his statements that claim to "re-evaluate the model of folk art, its bases and ancient wisdom", against "internationalism" and globalization" that invades worldly cultures of today.[135]

Indeed, while the organic architects who deal with the arcadian perspective prefer to display their environmental appropriateness by setting forth our primeval roots, the technicist ones are mostly interested in the technological implantation of their geodesic domes that are geometrical correspondent of Buckminster Fuller's belief in industrialization for the human survival. Indeed, according to David Pearson, Nicholas Grimshaw is one of the figures that represent the technicist tendency towards organic issues in architecture, which is according to him is clearly evident in his Eden project in Cornwall. Accordingly, the project ZED (Zero Emission Development) of the architectural office Future Systems might be another example

[135] David Pearson, 2001, *New Organic* Architecture, Dubai: Oriental Press, p. 168.

of the persistency of the organic issues in green architecture. It is designed as a high-rise office building with a plan in butterfly-shape. As the name of the office suggests, the project aims at minimizing the use of energy with the help of the wind-turbine erected at the core, as an energy generating device for the office as well as the surrounding buildings at the nearby environment. The organic style of the building is generated out of the wind flow patterns. The formal structure helps in the operation of the turbine, which is erected inside the large void at the center (Fig. 4.34). The void is surrounded by thick walls acting both as a noise insulator and as the supporting element of the circulation core. Hence, with this project, the Future Systems displayed the ways in which the technological implantation can be integrated with the formal structure in a green building.

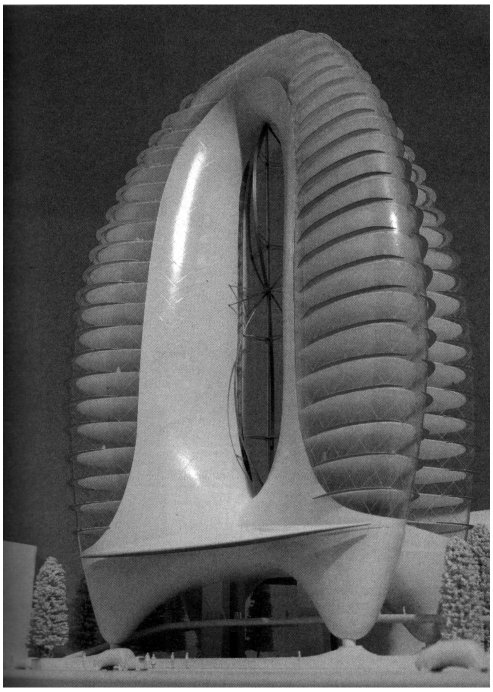

Fig. 4.34. Future Systems, *Project ZED,* London, 1995.

Source: Ed Melet, 1999, *Sustainable Architecture,* Rotterdam: NAI Publishers, p. 141.

In this chapter, the ways in which systems approach developed a philosophical background to the green architecture is discussed. It is observed that both Fuller's and Alexander's philosophical outlook towards systems issues find a place in the current green architectural arena. It is understood that the technicist dominancy in the appropriation of systems thinking to architecture continues today. Moreover, environmentally-conscious architects do refer to a coherent outlook as their ancestors of the 60s, who applied systems approach to their practices. Regionalist or arcadian frames of thinking exist in their discourse as well as the technicist ones. They do not seek for a theoretical consistency in their looking at environmental subject-matter; rather they aim at offering as much practical solution as possible to render architecture as a contributor of planetary healing.

CHAPTER V

CONCLUSION

Throughout the thesis, it is argued on the ways in which the systems approach, which was first theorized by the biologist Ludwig von Bertalanffy in the 50s, helps in the development of a coherent outlook for the architects who are interested in environmental subject-matter in architecture. The thesis puts forward a historical analytical survey of the appropriation of the systems approach in the discipline of architecture since the 60s. In the thesis, it is discussed that the today's green architects utilize the theories and methods put forward throughout this process of appropriation in their works, alongside the scientific terminology developed in the systems ecology. It is claimed that while architects who consider environmental issues as a moral initiative benefit from the equilibrium perspective of the systems ecology, the ones who claim to approach environmental issues from the aesthetic standpoint are interested in the terminology of disequilibrium approach.

The thesis evaluated the assumptions of certain theoreticians about green architecture. The first assumption is the lack of a philosophical background that supplants green architectural production. In the thesis, it is found out that the green architects benefit from the holistic philosophy that is developed by the post-war systems ecologists in producing their works; therefore, green architecture is not produced behind the lack of a philosophical framework. The second assumption is the technicist dominancy on the discourse, and the arcadian reaction against the dominion which caused a duality. It is found out and argued in the thesis that the technicist dominion and the resulting duality are the heritage of systems ecology to green architecture.

The thesis puts forward that green architectural production is mostly achieved by putting economical concerns at the center of attention. As mentioned in the Second Chapter, the equilibrium perspective in systems sciences emerged after the public awareness of the intense destruction caused by the Second World War. The main point of the equilibrium perspective is that the worldly phenomena are operated by a stable order, the annihilation of which may lead to apocalypse. The fear for extinction was hidden in the faith in the sustenance of our equilibrium condition. Indeed, as the historian Donald Worster informs us, the desire for stability invaded the social conjuncture of the era in which systems ecology was produced; that the willingness to maintain the status quo resulted in the envisioning of the economical structure as a systematically operating system in which every individual has a particular task[1]. Hence, it seems that the biologist Ernst Haeckel, while coining the word "ecology" according to its Greek roots, intuitively set up the state of ecology within the modern social system; as an economical paradigm. Meaning as the most economical means of dwelling on earth, "ecology" reflects the emphasis put on economic issues in the modern social structure. Throughout the thesis, it was understood that architects set their managerial attitude, which is a social construct that also affected the development process of systems ecology, under the service of economic system. For instance, the cost/benefit analysis, which is the one of the principles of systems ecologists in their investigations, was always considered by architects who are interested in the systems approach as a fundamental principle in the economic means of managing an architectural work. Concerning the subject matter, in the Fourth Chapter for instance, certain observations are outlined about the techniques of green production being used by architects to clean the reputation of certain corporations who put economic concerns ahead of environmental ones among the public.

[1] Donald Worster, 1995, *Nature's Economy: The History of Ecological Ideas,* Oxford: Oxford University Press, p. 315.

Throughout the investigations to decipher the assumptions put forward in the thesis, it is observed that the emphasis put on social and planetary stability in the systems ecology affected the religious beliefs of systems scientists, and that condition has a certain impact on architecture. As it was argued in the Second Chapter, systems ecologist James Lovelock admitted in his book entitled *The Age of GAIA* that his scientific experiments reinforces his belief in God, which according to him is a superorganic deity that puts an order to the corrupted human system.[2] Accordingly, the search of systems scientists for a universal order with the aid of divine power affected architects who are interested in systems approach as well. For instance, Buckminster Fuller writes that he developed his ideas under the care and willingness of the divine being, which he believed as having the cosmic power sufficient for ordering the energy system of our planet. Indeed, the teleological convictions reappeared in the architect Paolo Soleri's writings in which he claims for an aesthetical reconstruction based on the appraisal of a divine order in the cybernetic human system.

The Second Chapter enlightened the reader about the ways in which systems approach finds a place in the ecological sciences. The summary of the development of holistic philosophy in the systems ecology after the post-war period is put forward. The historical origins of the dominancy of the technicist paradigms and the arcadian reaction in systems ecology are entirely outlined. The chapter is mostly concerned with the equilibrium perspective of systems ecology as the contemporary green architects mostly utilize the equilibrium approach although it is refuted within the discipline itself. The equilibrium perspective puts that the steady-state environment is the assurance of human survival on our planet. Furthermore, the paradigm shift from the equilibrium to the disequilibrium perspective is outlined in the chapter.

[2] James Lovelock, 1995, *The Ages of GAIA*, 2nd ed., Oxford: Oxford University Press.

In the Third Chapter, it was discussed that the systems thinking began to invade architecture at the end of 60s, even though certain figures, such as Buckminster Fuller, initiated the research on the subject earlier than that period. It was claimed that the rationalist/technicist perspective dominated the 60s process of systems appropriation in architecture, and that condition was encountered with discomfort by certain architects who claimed that systems approach should be appropriated as a form of social enhancement, rather than the technological one. It was observed that the reactionary impulses are projected with regard to diverse forms of activism, such as self-built, regionalist ideas and vernacular revivals. It was argued that while the technicist wing was influenced from the theory of open systems, which is a part of systems approach, the social activist branch was affected from the theory of information. The theory of open systems in the systems ecology suggests the maintenance of a stable state of an organism, which is necessary for survival, with the help of its feedback systems. Likewise, technicist architects considered their buildings as a stable entity that sustains its feedback mechanism with the help of technology. The theory of information considered that the stability of a system is bound to the communication network of organisms in the process of energy exchange. Likewise, the social activist approach considered that the survival depends on the enhancement of social patterns of communication. They believed that architecture which projects the communication patterns of primeval societies, which were developed through the centuries of feedback response, helps to redevelop lost social relations in a modern setting.

In the Fourth Chapter, it is argued that the 60s utilization of the systems thinking in architecture is still influential in the contemporary green architecture. It is observed that the 60s appropriation of the systems discourse in architecture is achieved under the technicist supremacy and encountered with reaction that is projected by means of identical reactions of the social activist architects in the 60s. Throughout the Chapter, it is put forward that green architects make abundant use of both Buckminster Fuller's and Christopher Alexander's ideas, which represent diverting viewpoints and which were produced with the help of the systems approach. While the technicist green wing recycle theories provided by Fuller in particular, those who claim to set forth the social apprehension of green issues make use of Christopher's Alexander's claims to return to the vernacular tradition to develop social rigidity.

Moreover, it was claimed in the Fourth Chapter that today's architects do not seek for a theoretical consistency in their looking at environmental subject-matter; rather they aim at offering as much practical solution as possible to render architecture as a contributor of planetary healing. For instance, the green architects who represent the technicist wing sometimes integrate the discourses of reaction alongside the rationalist one. In the chapter, it was outlined how the architect Ken Yeang mentioned about the place identity of a region which he thought as being rooted in the primeval culture, while embellishing his skyscrapers with the most up-to-date technological tools. Or it was put forward how the architect William McDonough plants his buildings with arcadian gardens, while experimenting with his chemist partner on non-toxic material emissions.

In the chapter, it was argued that the ways in which the importance given to the economic criterion in the etymological origins of ecology affects the development of green architectural works. Moreover, it is argued that green architects entirely benefit from the equilibrium perspective of the systems approach, even though it was refuted within the scientific discipline itself. They select the most appropriate paradigm without any concern of their current validity to support their ideas on the environment. Throughout the chapter, it was put forward that they appropriate systems scientific discourse with reference to those who popularize ecological science, rather than to current scientific developments.

Furthermore, in the chapter, it was discussed that the contemporary environmentally-conscious architects, while shifting in the technicist and the reactionary positions, in a way conform to the systems ecologists of the postwar period which were struck between diverse viewpoints, as argued by the historian of ecology Donald Worster in his book *Nature's Economy.* As mentioned in the Second Chapter, Worster puts that systems ecologists projected both the "imperial" and "arcadian" positions that is the heritage of Enlightenment thought. The former position, according to him, was the dominant one among systems ecologists. It displayed a faith in the regenerative system of our planet through the help of our technological tools, which is the result of human intellectual capacity. According to Worster, this imperial attitude harbored an arcadian view of ecology, which was based on a primeval myth concerning the superorganic capacity of our planet that balances itself despite malicious efforts.

Hence, the outlook endowed us by systems ecologists is displayed in green architecture. In the Fourth Chapter, it was argued about how the anxiety brought forward by the post war ecology turned into optimism for survival among the technicists who utilize science and technology in their architecture. On the reactionary side however, the subject of discussion is the inevitable return of the human primeval condition as the result of abundant destruction of biodiversities. It is reflected in the revivals of the vernacular, the arcadian gardens and the self-built environments. The architectural works that set forth the reaction against technological dominion over environmental issues in a way project the corrupted condition of human morality as well. The demolished dwellings, which is invaded by plants, and the primitive houses, which is erected by the material provided from the surrounding, are depicted as part of the post-apocalyptic environment being the result of moral corruption. As mentioned in the thesis, Andrew Dobson, the environmentalist thinker, claims that doomsday views put the human being at the center of our survival system. Indeed, architecture reflects this fear for survival. Sometimes the reactionary techniques of construction are utilized by the technicist green architects as well. Such case is the architect Ken Yeang's allowance of plant invasion inside the atriums of his skyscrapers to clean the air that is lost in quality due to intense circulation inside spaces.

The Fourth Chapter concluded the thesis with the question: Does the paradigm shift in the systems sciences after the 80s has a certain effect on architecture? Basically, the paradigm shift in ecosystem science resulted in the assumptions that put an individual organism at the center of the systems discourse, rather than the ecosystem in totality. It is assumed that the future state of a certain occurrence is bound to an individual rather than a collaborative action. Accordingly, with reference to the certain theories on the subject, it is argued that those who project the paradigm shift in systems ecology to their architectural practices are not on the side of putting forward environmental problems in their work. Rather, their emphasis is upon conceiving architecture as hereditary cultural information passing from generation to generation. They believe that the strength of architecture for environmental awareness has parallels with the strength of message given as a cultural heritage. In this sense, architecture is conceived as having an iconographic value in visual means and aesthetic issues gain significance in this respect. In this chapter, it is argued that the revival of organic analogies is of concern in putting forward the expressive character of green designs.

Hence, in the thesis, it is suggested that the systems approach is appropriated to the realm of architecture as it is appropriated in the realm of ecology; with regard to particular cultural constructs. These cultural constructs are disparate, from rationalism and romanticism, which are incorporate philosophies of the Western Enlightenment thought, from the Feng-Shui and shamanism, which stem from the Asian religious doctrines. Architectural projects reflect the belief in human capacity and reason for the maintenance of earthly habitation. In the thesis, it was put forward that both rationalist/technicist and arcadian/primitivist perspectives are prompted by the aspiration towards the earthly repair and maintenance. The aspiration is reinforced with the wishful thinking that the road leading to survival is not full of gaps; that the superorganism earth will help humans in the maintenance process. From the self-sufficient buildings to the culturally diverse works, green architecture is under the service of this conviction that puts human at the center of everything. The disequilibrium architecture is also haunted by the desire for human endurance; that organic analogies are the assurance of formal diversities in architecture that are indeed the mirror images of the biodiversity of nature, which is considered by ecologists as necessary for a stable environment. In this sense, green architecture reflects the aspiration on long-term habitation of human being on earth, rather the one on environmental protection.

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