Relational Architecture
How can ecological-relational principles inform architecture?

Mrs. Batel Dinur

PhD

School of Architecture
University of Sheffield, UK

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Personal statement

I began writing this thesis with a very naïve question in mind: how can we design buildings that *feel* and behave like nature?
I have always been torn between the desire to be "in the wild", "in nature" and the desire to feel safe and protected within the walls of my own home. The aspiration to have both experiences at the same time led me to become an architect and to try and design such places. The love for nature and the desire to integrate between the two (nature and architecture) have left me dissatisfied with the solutions that I have managed to find, and finally led me to pursue this research. When I began to investigate existing literature on 'sustainable' architecture, I quickly became disappointed with their technical orientation and focus on operational practicalities rather than human *experience* of nature. I was interested in finding ways to integrate an understanding of human experience with scientific theories of ecology and ecological relationships. Is it possible to learn from nature how do design environments which provide flexible and evolving experiences? Is there a logical explanation to the way in which natural systems evolve that can be applied to the way we design architectural experiences?
My investigations were primarily led by subjective, intuitive formulation of ideas, which I then tried, in retrospect, to make logical sense of.
I truly hope that my investigative attempts do make sense, and that they manage to provide some clues to how we may design better architectural experiences - experiences that enable us to feel a degree of mystery and excitement, similar to those we feel "in nature."

Batel Dinur
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ABSTRACT

This research aims to investigate how an understanding of ecological behaviour in certain living systems can inform the design of the built environment. The main hypothesis that this research raises is that an understanding of living systems' organisation and behaviour can contribute to further development of the sustainable design discourse.

It is therefore within the scope of this research to offer an analysis and appropriation of ecological principles into the design field, with a specific focus on the built environment.

The research commences with an overview of some ecological principles, as they are manifested in natural living systems, continues with an evaluation of current sustainable architecture discourse and its possible drawbacks, and concludes with a suggestive application of the ecological principles into architectural design. It is assumed that by being exposed to ecological principles of behaviour, architects and designers may begin to appreciate their importance and relevance to the design disciplines, and especially to architecture, which functions as a built, environmental interface between natural and behavioural processes, and for this reason – should arguably be able to reflect both.

This research aims to provide a methodology for the application of certain ecological principles into the built environment by viewing architectural principles as an interface between people and nature. Therefore, the ecological principles will be applied to the *relationships* between already existing natural processes on site and the people that interact with them ('the users'). The architectural system, then, becomes a platform on which these relationships are manifested.

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1. General Introduction to thesis

Sustainable architecture, according to the way in which it is defined within the architectural design discourse, aims to provide an alternative design paradigm to current, prevalent wasteful and unsustainable design practices. It is based on a revised conceptualisation of architecture which takes into consideration environmental issues by offering a variety of practical solutions to the environmental problems caused and triggered by the built environment (Williamson et al. 2003: 1).

It is the assumption of this thesis that sustainable architecture can benefit from adopting an ecological view through the understanding of ecological relationships. This can potentially move architecture away from its obsession with form, as an object, into a possibility of considering architecture to be a manifestation of relationships, taking place within the environment.

It is therefore the aim of this research to investigate how ecological principles of relations may be interpreted in a way that can inform architectural thinking.

Ecology, as the scientific branch which investigates the relationships between living organisms and their environment, may prove to be relevant for architecture by opening up new possibilities for investigating the relations that exist between people and their environments (both natural and built) in accordance with ecological principles. By drawing parallels between ecology and architecture, architects may be able to begin to envisage human environments as an interplay of forces, taking into account both human needs as well as the 'needs' of the natural environment (as it is currently understood by humans).

The study of ecology reveals a multi-layered, interdependent, complex structure among living systems which, in most cases, supports and encourages further growth of those systems in a way which also tends to enable further growth of their supporting environments. Applying ecological principles into architectural design thinking, by focusing on the relations that architecture enables between people and nature, may open up a possibility for architects to view architecture as an integral part of its wider natural and social environments, rather than in isolation to it.

This hypothesis will be explored in the third and forth sections of this thesis, through a theoretical analysis of ecological relations in architecture and their application within a specific context (i.e. a case study).

The application of the ecological principles into architectural design thinking will first be described, in section three, by:

1. Distinguishing between natural processes and behavioural processes.
2. Exploring the possible interrelations between natural and behavioural processes.
3. Suggesting how architecture may support ongoing interrelations between natural and behavioural processes.

The overall argument in this thesis will proceed according to four main sections:

Section One will explore nine ecological principles, which together provide a comprehensive view of living systems' organisation and behaviour.

Section Two will review current approaches within the sustainable architecture discourse in relation to: nature, people ('users') and the interface between them.

Section Three will provide an analysis of the nine ecological principles (described in section one) in the context of architecture, by focusing on the relations that architecture may enable between people and nature.

Section Four will attempt to apply the ecological principles, as interpreted in section three, to a specific case study, in order to test and clarify their contextual applicability.

2. Introduction to Sustainability and the Ecological model

2.1 The origins of 'Sustainability'

Sustainability may be regarded by some as the first step towards a cultural ethical shift; from an ethic which is concerned primarily with present-time human well-being - to an ethic which begins to look wider and consider the well-being of future generations as well.

> Underlying most ethical thought at present is the assumption that human life is the summum bonum. Perhaps it is; but we need to inquire carefully into what we mean by "human life." Do we mean the life of each and every human being now living, all 4,000,000,000 of them? Is each presently existing human being to be kept alive (and breeding) regardless of the consequences for future human beings? So, apparently, say amiable, individualistic, present-oriented, future-blind western ethicists.
> An ecologically-oriented ethicist asks, "And then what?" and insists that the needs of posterity be given a weighting commensurate with those of the present generation (Hardin, 2001: 55).

Hardin's most popular article 'The tragedy of the commons' first published in 1968, introduced the possible destructive consequences of further human population and economic growth (Hardin, 1968). Sustainability, as an idea, began to emerge around the same time, when people slowly became aware of the fact that their actions in the present may have far-reaching destructive consequences on future generations. Rachel Carson's Silent Spring published in 1962, brought to light the effects of chemical pesticides on the natural environment and caused much controversy over their continuous usage (Steele, 2005: 164).

First 'Earth day' in June 1970 brought basic environmental issues to public awareness (Steele, 2005: 165), followed by "Limits to growth" - a report published in 1972 by the Club of Rome think tank, which focused on the idea of progress and, in particular, on the fact that global industrial activity was increasing exponentially, predicting drastic consequences if such growth were not altered, such as the irrevocable loss of non-renewable resources (Steele, 2005: 165). Additional new ideas about the problems associated with continuous growth continued to emerge during the 70's, but it was not until 1987 that Sustainability was, for the first time, publicly defined and discussed as an issue of global concern. The Brundtland report ("our common future") published in 1987 dealt with the concept of sustainability, which was defined as the principle that economic growth can and should be managed so that natural resources be used in such a way that the 'quality of life' of future human generations is ensured (Steele, 2005: 167).
The idea of sustainable development, as suggested by the Brundtland report, which involves 'those paths of social economic and political progress that meet the needs of the present without compromising the ability of future generations to meet their own needs' (Brundtland, 1987), is still the most common definition of sustainability, and one which has been adopted by big governments within the developed world.

2.2 The concept of 'Sustainable development'

Some may argue that 'sustainable development' is a problematic mission, since 'sustainable' and 'development' are two contradicting terms. The initial definition of sustainability as a pathway from which both present and future generations will benefit may prove to be unattainable if the current modern model of development remains the leading ideological model for society. According to Spretnak, the current model of modernity is based on an individualistic pursuit of self-interest, which is highly detached from the natural world;

> Modern man emerged as a detached manipulator of the rest of the natural world, bringing to bear a humanist focus that located all value in human projects. His secular, rationalist sensibilities created an ideal of liberalism based on the individual pursuit of self-interest. His unsentimental recognition of homo economicus cleared away past restraints with a new dynamism: If each man sought his best monetary advantage, all society would benefit. Having advanced beyond the muddled, infantile beliefs of former times, modern man would be supremely poised to lead the way into unprecedented moral and material progress (Spretnak, 1997: 59).

Spretnak further suggests that this modern model has become so ingrained in society that anyone who points to its failures seems to threaten our common identity and our covenant with progress (Spretnak, 1997: 131).

Sustainable development does suggest that there need not be any inherent conflict between economic growth and ecological awareness and offers, in principle, a compromise between 'growth' and 'no-growth' factions (Steele, 2005: 165). Sustainable development can therefore be viewed as an appealing concept, mainly because it does not threaten existing social and economic structures which promote progress and continued economic development.

Williamson et al. (2003: 81) suggest that much of the way in which we look at sustainable development is predicated on a scientific approach. It feeds on a belief that a solution can be found for almost anything and that progress and development is the way forward. It relies on the assumption that a sustainable way of life will solve environmental problems, but the true meaning and implications of sustainability remain vague. As Orr suggests: "We cannot know what sustainability means until we have decided what we intend to sustain and how we propose to do so" (Orr, 1992: 426).

The fact that 'sustainable development' is a confusing statement appears to benefit its aims. It allows growth and development in the modern world to continue, while at the same time some measures are being taken and policies implemented to protect and preserve the natural environment so that its continued survival is ensured.

2.3 The nature of linear development vs. the concept of sustainability

The main reason for the apparent failure of the sustainability movement to substantially reduce environmental degradation is that it did not manage to transcend existing models of economic development. Rather, it slowly became an inherent part of the prevalent economic cycle (Wood, 2007). Sustainable products and systems soon became part of a remedial cycle of consumerism, promoting a "green lifestyle" which offered a new niche for producing yet more public goods (Manzini, 2003: 7). The complexity of the modern economic model, which is based on an ideology of collective growth achieved through the pursuit of individual self-interests, meant that any attempt to introduce sustainability criteria into it would end up merely as a "new trend" that promotes yet more individual and collective progress.

This means that even though new environmental policies are applied and more questions are asked about the negative effects of industrial and technological procedures, the overall tendency for growth and development continues. This poses one of the major paradoxes that the sustainability movement is currently faced with. The implications of the continued accelerated growth on natural systems is one of the major problems which sustainable development has not been able to solve. It is a fact that the accelerated timescale associated with modern development does not correspond to the timescale of the natural world, and the effects of human activity impose major stress on ecological systems;

> The time scales of modernity have collided with the time scales that governed life on Earth in premodern times. Every year, our industrial systems burn as much fossil fuel as the Earth has stored up in a period of nearly a million years. At this rate, we'll use up all of the planets fossil fuel reserve within the equivalent of a second in geological time. The acceleration of the speed of human

> population growth means that in a single human lifetime, the Earth may lose half of its living species, species that it took tens of millions of years for evolution to create through the process of speciation (Thackara, 2005: 31-2).

The lack of correlation between human industrial and technological developments and nature's pace of development is one of the major environmental problems that human culture is currently faced with and one which sustainability has not succeeded so far in addressing. While modern notions of progress and development tend to promote a linear notion of time, natural ecological systems tend follow a circular notion of time which is based on feedback loops and repetition.

Williamson et al. introduce the difficulty of reconciling the two notions, which is apparent in the contradictory concept of 'sustainable development;'

> Sustainability indicates caretaking and maintenance, the repetition of certain procedures. In this respect sustainability implies a circular notion of time. Development on the other hand is in our culture connected to a continuous accumulation of capital, material, services, knowledge and anything that is commodified. Accordingly, development implies a linear notion of time. Is it possible to integrate those two comprehensions of time into one concept? Can a circle be a straight line? (Williamson et al., 2003: 55)...

It becomes apparent at this point that the notion of sustainability and the notion of linear development are conflicting. Linear modelling, according to Stewart, "breaks processes down into parts, and looks for how simple step-by-step interactions between the parts can be used to predict how the process will unfold under different conditions. Analysis, reduction and logical deduction are its basic tools" (Stewart, 2000: 94-5). This type of linear modelling makes it difficult to encompass notions of circularity, repetition and maintenance into it.

A compromise which utilises both models is suggested by Orr (1992). According to his view, the linear model can have a positive effect on the environmental crisis in the short run, by using the existing hierarchic power structures and linear methods of development to exert immediate influence in relation to environmental problems ("an efficiency revolution which buys us some time"), while at the same time, putting into effect long-term goals, which will require more fundamental changes in modern culture's organisation and values ("a long-term sufficiency revolution") [Orr, 1992: 430].

2.4 The problem with change

The linear model of development, which largely defines the structure of modern culture, is very difficult to challenge. Initially, due to the fact that linear ideas have been the basis for the technical-rational ideology that has guided modern society ever since the late 16th century (these ideologies will be further explored in section two). Secondly, because "proposals for change usually address only an aspect of the whole, so that work continues within the same overall frame and expectations" (Beach, quoted in Williamson et al., 2003: 133). This problem was exemplified in the previous paragraph, whereas the attempt to introduce the concept of 'sustainable development' only generated more action that has been based within a larger problematic linear ideological framework. And thirdly and maybe most convincingly, is the fact that there is no clear alternative model for action that challenges the linear, development model. As Dubos realised over thirty years ago:

> Ecological problems are difficult to deal with because we lack methods for investigating scientifically the interrelatedness of things (Dubos, 1970: 174).

The linear model of development and growth[1] probably still presents itself as the safest and most clearly tested model around. People will tend to continue and believe in its ability to perform fairly well and prefer its familiarity and stability to an unclear and risky experimental model. It is therefore an important mission for the critics of the linear model to offer a convincing and inspiring new model as an alternative. Not a model which offers compromise, as the classic model of sustainability does, but a model which offers a true alternative, a long-term vision for a better world.

[1] Which is largely based on a scientific, technocratic model (See discussion on technology in section two)

2.5 The Ecological World-view

The ecological view, unlike sustainability, aims to offer a comprehensive alternative to previous linear models by building on principles and concepts from the science of ecology, in a way that allows apparently unrelated world phenomena to be perceived as interdependent and mutually enhancing. Ecological philosophy may be able to offer a possibility to integrate various human-centred social and cultural processes with ecological natural processes without either one compromising the other's potential for growth and development[2]. In fact, ecological principles suggest that the greater the variety of systems an environment can sustain, the greater the potential of that environment to survive and evolve over long periods of time. This entails that rather than viewing differences between components or systems as a source of conflict (as is currently apparent between natural and modern-cultural constructs), ecology suggests that differences within an ecological community are usually manifested as a source of strength for the system (Capra, 1997: 295).

The aim of the ecological view, therefore, may be to clarify how the science of ecology can inform the construction of various social and cultural processes in a way that enables them to better integrate with natural ecological processes.

The following table by Spretnak positions the ecological view in comparison to modern and deconstructionist views of the world. It helps in illustrating some of the possible basic cultural, social and ideological differences between the three views.

[2] The close link between Ecology and Culture was first introduced by Julian Steward in his ideas on *Cultural Ecology* (1955).

	Modern	Deconstructionist Postmodern	Ecological Postmodern
Meta-narrative:	Salvation, progress	None (They're all power plays)	The cosmological unfolding
Truth mode:	Objectivism	Extreme relativism	Experientialism
World =	A collection of objects	An aggregate of fragments	A community of subjects
Reality =	Fixed order	Social construction	Dynamic relationship
Sense of self:	Socially engineered	Fragmented	Processual
Primary truth:	The universal	The particular	The particular-in-context
Grounding:	Mechanistic universe	None (total groundlessness)	Cosmological processes
Nature as...	Opponent	Nature as wronged object	Nature as a subject
Body:	Control over the body	"Erasure of the body" (it's all social construction)	Trust in the body
Science:	Reductionist	It's only a narrative!	Complexity
Economics:	Corporate	Postcapitalist	Community-based
Political focus:	Nation-state	The local	A community of communities of communities
Sense of the divine:	God the father	"Gesturing toward the sublime"	Creativity in the cosmos, ultimate mystery
Key metaphors:	Mechanics, law	Economics ("libidinal economy"), signs/coding	Ecology

Table no. 1 (Spretnak, 1997: 73)

The above table clarifies the main ideas of the ecological view as a model which is grounded in cosmological processes, thereby positioning the ecological concept not only as a metaphor for complex processes, but also as a context for all human actions. Cosmology's role in human society may be defined as a way to "orient a community to its world, in the sense that it [cosmology] defines, for the community in question, the place of humankind in the cosmic scheme of things. Such cosmic orientation tells the members of the community, in the broadest possible terms, who they are and where they stand in relation to the rest of creation" (Mathews, 1991: 12).

The Norwegiam philosopher and founder of the 'deep ecology' movement Arne Naess describes eco-philosophy as "the emergence of human ecological consciousness" and acknowledges it as a philosophically important idea since: "a life form has developed on Earth which is capable of understanding and appreciating its relations with all other life forms and to the Earth as a whole" (Naess, 1989: 166).

Therefore, the understanding of human actions in relation to broader natural and cosmological processes can be described as one of the main aims of the ecological view. It implies that human culture should become a subset of wider ecological and cosmological processes;

> Despite its abstractness, then, a culture may act as a naturally selected instrument of Nature, or participant in the local ecosystem. The society which practises such a culture, tied to a particular region and a particular set of ecological relations, may thus qualify as a self-maintaining system - since it successfully perpetuates its own social structures by means of its belief system - and thus as a holistic subsystem of the local ecology (Mathews, 1991: 139).

The ecological world-view, then, offers an alternative model for action, which goes further than sustainability. It aims to replace rather than conform to existing linear development models, by promoting an ecological and cosmological grounding of human culture in its local natural context instead of trying to transcend natural processes through a rational model[3] of continuous progress.

[3] The origins and implications of the Western ratio-technocratic model will be further explored in section two.

3. Current notions of sustainable architecture

3.1 The sustainable agenda in architecture

Buildings are generally considered to be responsible for at least half of the world's energy consumption. The environmental impacts of buildings can be assessed in relation to three main stages: the construction phase, the usage or occupation phase, and the disposal/demolition phase. There are a variety of data sources worldwide which assess the exact impacts of buildings during these three stages, and one of them, in relation to buildings in the UK, states the following facts:

1. Buildings are responsible for 50 percent of primary energy consumption.
2. Buildings account for 25 percent of sulphur and nitrogen oxide emissions and 10 percent of methane emissions.
3. In 1997, the construction industry was responsible for 16 percent of the water pollution incidents in England and Wales.
4. Construction work on site is responsible for 4.7 percent of noise complaints.
5. 6 tonnes of materials per person are used for construction.
6. 30 million tonnes per year of excavated soil/clay waste are estimated to arise from construction site preparation.
7. 30 million tonnes of waste arise from demolition work each year (Howard, 2000).

These harmful influences of the building industry on the environment, coupled with increasing urbanisation worldwide, have gradually led to a re-evaluation of prevalent planning and building strategies and methods, which have resulted in some of the current approaches to "sustainable architecture."

> Sustainable architecture, then, is a revised conceptualization of architecture in response to a myriad of contemporary concerns about the effects of human activity. The label 'sustainable' is used to differentiate this conceptualization from others that do not respond so clearly to these concerns (Williamson et al., 2003: 1).

Some regard the 'mission' of sustainable architecture to be even wider than a mere practical agenda that addresses sustainability concerns within the building industry. Wines envisages sustainable architecture as parallel in its intensity to early modernism, through its attempt to reconnect people to nature on a conceptual as well as practical level: "If designers of the 1920s and 30s could develop a persuasive architectural language out of the rather limited (by comparison to nature) inventions of industry, imagine the wealth of ideas to be found in the complexities of terrestrial and cosmological phenomena" (Wines, 2000: 19). He regards the possibilities in adopting an environmental stance in architecture to be as varied as the richness that can be found in nature and in the possible relations that humans may have with nature.

3.2 Different approaches to sustainable architecture

Although there is a general consensus about the need to make architecture more sustainable, in order to address current environmental problems, there are disagreements about the extent to which architecture should take on board the environmental flag, and about the appropriate methods for implementation. Sustainability in architecture is generally seen either as a 'motto,' a very central issue in the design, or as a by-product, an additional feature or problem that needs to be addressed during the design process. According to Hagan, among those who take sustainability as their main concern, there are two distinct groups;

> 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 (Hagan, 2001: intro).

As Hagan continues to explain, the intent in investigating pre-industrial buildings does not necessarily stem from a romantic or idealistic view of the past, but engages in an attempt to see pre-industrial and vernacular architecture as a source of valuable principles and tried and tested techniques of passive environmental design (Hagan, 2001: 103). Steele (2005) even goes on to suggest that the environmental tradition in architecture is as old as architecture itself and backs up his assertions with a variety of examples from different architectural disciplines (including modernism).

The variety of attitudes and possibilities of applying sustainability concepts in architecture contributes both to its popularity as well as to the confusion that surrounds its lack of precise definition. Rather than attempting to address solely practical environmental problems, sustainable architectural definitions may vary to include some new interpretations of social, cultural and technological issues. Williamson et al. (2003: 25) present three different prevailing images of sustainable architecture:

> *(1) The Natural image* - its main concerns relating to ecosystems' health and balance. Emphasizing sensitivity and humility in relation to nature (e.g. Gaia architects, Brenda & Robert Vale).
> *(2) The Cultural image* - its main concerns relating to local place and people. Emphasizing local building culture, local involvement and expertise (e.g. Christopher Day, Andrew Yeats).
> *(3) The Technical image* - its main concerns relating to global impacts and technological solutions. Emphasizing science, economics and trans-national expertise (e.g. Richard Rogers, Ken Yeang, Normal Foster).

All of those three images are currently labelled as 'sustainable architecture' but each one of them interprets sustainability differently.

3.3 The main drawbacks

As much as sustainable architecture[4] may seem to be appealing in its mission to minimize environmental problems and integrate better with natural and cultural processes, it is not so easy to implement. One of the central reasons for this difficulty is the fact that architecture is not an isolated activity. It is dependent on and affected by many areas of life, not all of which participate in the sustainability agenda. This makes it very difficult to implement new "sustainability" policies within the building industry. It requires government support, developers' willingness to invest, new building and engineering knowledge, and social awareness to sustainability issues (including social and economic problems which sustainability encompasses). The process of bringing all of these factors under the same practical and ideological agenda requires integrated policies and willingness which are currently difficult to achieve. Alongside a bottom-up process of cultural transformation and changing awareness there is a need to implement a top-down process of policy change driven by international obligations (Beach, as quoted in Williamson et al., 2003: 134). By the time such a policy change is implemented worldwide, many individual attempts are being made by designers to research into possible environmentally friendly products. Such attempts are highly important for development in the direction of increased awareness to sustainability, but disappointments about the slow acceptance of these products and services in the design and building industries frequently arise. The reason for the slow acceptance of such environmental designs is, according to Thackara, due to their intervention at the "end of the pipe." The modification of individual products or services does not transform the building and industrial processes as a whole (Thackara, 2005: 18). Others similarly argue that sustainable design

[4] 'Sustainable architecture' here is referred to in its widest sense, including all possible interpretations of it (i.e. cultural, natural or technological).

has failed to induce any real change within society due to larger economic processes driven by a belief system in which human agency is perceived as all-powerful (Wood, 2007). "Up to now, every attempt to invent a mode of 'design for sustainability' has been marginalised, appropriated, and subverted within a wasteful market system in which designers must uphold the status quo" (Wood, 2007: 3). The fact that sustainable design represents a small and rather specialised professional field within a larger social and economic framework that does not support it impedes its chances to proliferate and succeed.

An additional obstacle in the way of sustainable design's wide acceptance is its misinterpretation by some designers and the public alike. Critics of sustainable design like to claim that it tends to interfere with creative freedom by its tendency to produce too rigid guidelines for design – limiting choices of materials and building techniques as well as discouraging the use of new technologies (Abley, 2001). Others dislike the fact that sustainability is becoming a label for efficiency, forgetting its deeper and wider consequences. Some environmental design methodologies, such as: Life Cycle Assessments (the assessment of all environmental impacts of materials from their manufacture to their disposal), Environmental Profile Methodology (a method designed to evaluate the environmental impacts of construction methods), Embodied Energy (the total energy required to manufacture as well as transport materials), and others, frequently give the impression that sustainable design's only concern is in applying efficiency regulations in relation to buildings and products' environmental impacts. Some environmental design approaches often advocate these efficiency regulations as the sole and most important aspect which sustainable design should be concerned with: "From the point of view of applied ecology, ecological design is essentially to do with energy and materials management concentrated on to a particular locality"

(Yeang, 2006: 67). It therefore may come as no surprise that many designers and architects are being put off by such tight regulations and technical measurements, which appear to be the only message that sustainable design carries.
In fact, incorporating practical environmental measurements criteria, as those described above, into design solutions, can be argued to comprise only a part of a comprehensive sustainable design solution. Initially triggered by environmental concerns, sustainable design may be considered to have evolved into a type of design solution which takes into consideration many ethical aspects of design consequences. These may include cultural, social and economic aspects as well as environmental and technological ones. As some sustainable design advocates argue: "The challenge for the future is to address sustainability in a holistic rather than a piecemeal fashion" (Sassi, 2006: 2).

It is therefore the hypothesis behind this thesis that an understanding of ecological systems' organisation may enable architects and designers to think about sustainability in a more holistic and complex way, by employing ecological principles to explore interdependencies among various processes, that may include some or all of the following processes: natural, social, cultural, technological and economic.

The next section of the thesis will attempt to provide an overview of some basic ecological principles, by dividing them into three main over-arching principles:

1. The relation between the part and the whole in ecosystems.
2. The relational dynamics among the parts.
3. The phenomena of growth in living systems.

4. Introduction to Section One

The aim of the following section is to introduce some basic principles of ecology, as they are manifested in ecological systems' behaviour, and which, according to this thesis' main hypothesis, might prove to be beneficial if introduced to sustainable design thinking.

Natural ecological systems function in a way which enables them to constantly grow and develop without compromising the basic conditions that sustain their lives. They have an inherent tendency to support and compliment the growth of their sustaining environment while they develop.

Human cultural constructs, whether social, economical, political, or architectural, can potentially benefit by emulating and integrating ecological principles into their currently linear, mechanistic-driven structures. This is not only for the advantage of integrating better with natural processes, but also for the potential to function more successfully as interrelated processes, with one another. As Capra argues;

> The more we study the major problems of our time, the more we come to realize that they cannot be understood in isolation. They are systemic problems, which means that they are interconnected and interdependent. For example, stabilizing world population will only be possible when poverty is reduced worldwide. The extinction of animal and plant species on a massive scale will continue as long as the Southern Hemisphere is burdened by massive debts (Capra, 1997: 3).

This interconnection between apparently unrelated socio-economical problems reveals two things; one is, that on some level, the world at large functions as a coherent interrelated ecosystem, and the other is, that the relationship between cause and effect is more complex than a mere linear connection between two points.

Similarly, in architectural discourse, problems associated with sustainability issues, such as natural resource depletion and increased energy consumption, may in fact, be closely related to and influenced by a set of socio-cultural issues related to Western cultural values, such as; individualism, consumerism, technocracy, etc.

Understanding ecological principles, from a scientific perspective, can shed light on the way in which very complex living structures can develop in an inter-disciplinary manner, by cooperation rather than competition. Similar applications of ecological principles to various disciplines have already been made theoretically (although not always acknowledged as 'ecological,' but certainly manifesting at least several eco-principles) in areas as varied as: Education (Orr, 1992; O'Sullivan, 1999; Keiny, 2002), Business (Senge, 2005), Engineering (Sendzimir, 2002), Psychology (Bateson, 1979), Sociology (Bookchin, 1993; Schumacher, 1973), Economics (Arthur, 1999; Becker, 2006), and Medicine (Gadow, 1992).

For example, in the field of economics, ecological principles and complex systems' thinking have influenced traditional modelling. Brian Arthur, a Professor at the Santa-Fe Institute has developed the idea of positive feedback ("increasing returns") and its influence on the economic system. According to his models, changes of individual agents' predictions within the economy "ripple through the market in avalanches of all sizes, causing periods of high and low volatility" (Arthur, 1999: 4). His conclusions prove that models of the economic system which are based on complex systems, and which model markets as "mini ecologies" manage to portray the economy "not as deterministic, predictable and mechanistic; but as process-dependent, organic and always evolving" (Arthur, 1999: 4). Other implications of ecological principles within economics include a re-evaluation of the relationship between the economy and nature, and the role of humans in facilitating this relationship. Becker speaks of

economics as "a creative process and creativity as an essential characteristic of the human being, which connects it and its economic actions with nature" (Becker, 2006: 21).
Similarly, in education, the ecological model has been adapted by various researchers. One of the first promoters of 'ecological literacy' in education is David Orr (1992) as well as O'sullivan (1999). Others, such as Keiny, for example, attempted to utilise ecological principles in order to redefine the education system as a "multileveled web of relations between various groups" (Keiny, 2002). In her experiments, Keiny tested the interrelations between three contexts for learning - one was an interdisciplinary reflective group of researchers working together, the second was an experimental context to try out ideas (a classroom, for example), and a third was the internet as a connecting tool for communication. She then integrated several ecological principles into her education model: self-organisation, subjective observation, reflectivity, indeterminism, environmental context, causality, holism and interaction (Keiny, 2002: 183).
In architecture, many theorists and practitioners often refer to 'ecological architecture' as a type of architecture which aims to integrate better with nature and natural processes. However, these approaches rarely manifest ecological principles in the way they are observed and understood from the behaviour of living systems.

The following section will aim to clarify some basic ecological principles. Ecological principles vary in their scope and interpretation. The aim of their investigation in the context of this thesis is to try and formulate an understanding of their basic *organisation*. How is it different from the organisation of linear and mechanistic systems? What enables ecological systems to remain homeostatic and dynamic at the same time? How is their very complex organisation manifested in a way that can be easily explained? These main questions informed the research into ecological and complex systems' organisation, which led to the following division of the ecological principles that had been discovered into three main chapters, which together aim to provide an overall insight into the basic organisation of living systems. These chapters are described as:

1. *Part/whole* - the first chapter will examine the *basic relationship* that exists between any component/part of a living ecological system and the system as a whole.
2. *Relational dynamics* – the second chapter will examine the *type of relations* that exist between the components in an ecological system, i.e. how they relate to one another and how they maintain coherence within the system.
3. *Emergence* – the third chapter will examine the *phenomenon of growth* that most living systems manifest, and how this phenomenon is supported by the type of organization that living ecological systems embody.

The proceeding exploration of ecological principles, according to the three chapters, is drawn from a variety of theoretical sources on ecology and systems theories. Most of the writers drawn from are scientists, with a background in biology, physics, ecology, and cybernetics, while a minority are philosophers and theorists with a specialisation in eco-philosophy or systems' theories.
It is assumed that an exposure to the behaviour of living, ecological systems, described according to the three following chapters, will enable, later on, their application into architectural environments, as will be attempted in the third section of this thesis.

5. The principle of Part/ Whole

One of the basic defining relationships within an ecosystem is the relation that exists between the components or parts of the ecosystem and the encompassing system as a whole. This relationship will be explored according to the following three defining principles: (1)Interdependence (2)Purposefulness, and (3)Autopoiesis.

5.1 Interdependence

The definition of ecology as a science was first coined in 1866 by the biologists Ernst Haeckel, and was later developed by Odum (1953) and Krebs (1972). Ecology is considered to represent the highest stage in the organisation of living systems within their environments (Vizel, 1983: 8). The ecological system as a whole is considered to be an open system, which can continuously develop and produce new forms of organisation, by interacting with the environment and changing in accordance with it (Vizel, 1983: 9).
A natural ecological system can be defined as a "functional unit that results from the interaction of biotic factors (plants, animals and micro-organisms) and abiotic factors (air, water, rocks, energy)" (Eblen and Eblen, 1994: 185). The inclusion of abiotic factors in the definition of the ecosystem signifies the importance of what is often referred to as *the environment* in the development of natural ecosystems. Therefore, the Earth's biosphere, including the atmosphere (air), hydrosphere (water), and litosphere (land), constitutes a unified, feedback system between living things and their physical and chemical environments (Eblen and Eblen, 1994: 185). This definition of the Earth as a unified ecosystem was first introduced through the *Gaia hypothesis*. Developed by the scientist

James Lovelock and microbiologist Lynn Margulis, the Gaia hypothesis (named after the Greek goddess of the Earth) claims that the Earth is a unified homeorhetic[5] system, which possesses the ability to control and maintain satisfying conditions for the continuation of life. According to Lovelock and Margulis's Gaia hypothesis

> The surface of the earth, which we've always considered to be the *environment* of life, is really *part* of life. The blanket of air – the troposphere – should be considered a circulatory system, produced and sustained by life... when scientists tell us that life adapts to an essentially passive environment of chemistry, physics, and rocks, they perpetuate a severely distorted view. Life actually makes and forms and changes the environment to which it adapts. Then that 'environment' feeds back on the life that is changing and acting and growing in it. There are constant cyclical interactions (Capra, quoting Margulis, 1997: 106).

According to the Gaia hypothesis there is no significant difference between living organisms and the environment which sustains them (which includes abiotic components) in terms of their capacity to adapt to changing surrounding conditions. So each one (the organism and the environment) is an active participant in the maintenance of the overall system of Gaia.

These assumptions were well illustrated by the daisy-world simulations, conducted by Lovelock in 1983. The 'Daisy-world' simulated a hypothetical planet inhabited only by light and dark daisies, which cooperated to keep the temperature of the planet more or less stable. If the temperature is too cold (below 5 degrees) the daisies will not be able to grow, and if it is too hot (above 40 degrees) the daisies will die. The amount of light and dark daisies dominating the population altered in a way that maintained an average temperature of 20 degrees, which was the optimum temperature for their growth. The number of dark daisies increased

[5] Homeorhesis refers to a restoration of flow in systems (Encyclopedia Britannica).

when the temperature dropped, thereby absorbing more sunlight and causing an increase in temperature. Once the temperature started to rise beyond the desired level, the amount of light daisies increased, thereby reflecting the excess sunlight out to space. This experiment proved that Gaia (simulated by the daisy-world) had an inherent capacity to regulate its own conditions in order to ensure the optimum conditions for life (Lovelock, 1979). Gaia is a name for the entire large ecosystem of the Earth which is composed of smaller ecosystems that function in a similar regulatory manner to that of Gaia. Each ecosystem is composed of living organisms and living environments which function together as a whole system.

The significance of the Gaia hypothesis is in stressing the two-way interaction between organisms and their environments and in acknowledging the regulative interdependence between ecosystems on earth; "Each species to a lesser or greater degree modifies its environment to optimize its reproduction rate. Gaia follows from this by being the sum total of all of these individual modifications and by the fact that all species are connected, for the production of gases, food and waste removal, however circuitously, to all others" (Lynn Margulis, quoted by Lovelock, 1979: 120).

Although controversial when it was first published, the Gaia hypothesis is now largely considered as a valid scientific hypothesis (Turney, 2003) although some controversies still continue. The Gaia hypothesis, since its publication in the late 1970s, has been developed and studied, and is sometimes referred to as Geophysiology or Earth system Science, which takes into account interactions between biota, the oceans, the geosphere, and the atmosphere.

Humans are also part of the regulative Gaian system and they have, as a whole species, a larger capacity than any other community of living organisms to interfere with the regulative operation of Gaia, as Lovelock explains;

> The larger the proportion of the Earth's biomass occupied by mankind and the animals and crops required to nourish us, the more involved we become in the transfer of solar and other energy throughout the entire system. As the transfer of power to our species proceeds, our responsibility for maintaining planetary homoeostasis grows with it, whether we are conscious of the fact or not. Each time we significantly alter part of some natural process of regulation or introduce some new source of energy or information, we are increasing the probability that one of these changes will weaken the stability of the entire system, by cutting down the variety of response (Lovelock, 1979: 123).

When humans chop down a rain-forest, for example, they set in motion a chain of natural events (changes in nutrients, soil, species, etc.) that are likely to come back and form a new pattern for us to adjust to, such as global climate change.

The notion of the interdependence between the part and the whole, as exemplified through the Gaia hypothesis in relation to the Earth and its composing ecological systems, is also echoed in other scientific disciplines. The physicist David Bohm developed a theory of wholeness in theoretical physics. In his influential book *Wholeness and the Implicate order* (1995) he argues that primacy is given to the undivided whole, and the implicate order inherent within the whole, rather than to the particles or the parts of the whole. For Bohm, the whole encompasses all things, structures and processes, and parts can only be considered in terms of the whole. The parts can be regarded to constitute relatively autonomous and independent "sub-totalities," but nothing can be considered *entirely* separate or autonomous;

> Each relatively autonomous and stable structure is to be understood not as something independently and permanently existent but rather as a product that has been formed in the whole flowing movement and that will ultimately dissolve back into this movement. How it forms and maintains itself, then, depends on its place and function in the whole (Bohm, 1995: 14).

Interdependence between the 'parts' (components) and the 'whole' (the bigger context of their existence) can be regarded as a basic condition for the existence and development of living systems. No living system can exist in isolation from its environment. It is initially formed as part of a bigger context and continuously evolves, throughout its lifetime, as part of a context.

The idea of interdependence between part and whole can inform architectural design by stressing the *inherent interdependence* between people and their natural environments. Rather than designing architectural environments as isolated physical structures, an understanding of the ecological principle of interdependence can suggest a possibility of designing architectural environments, which reveal rather than ignore the *interdependencies* between people and their wider natural surroundings. The possibilities of utilising the principle of interdependence through architectural design will be further explored in the third and forth sections of this thesis.

An understanding of the basic ecological interdependence between part and whole within ecosystems can be further explored through the idea of *purposefulness*. What is the "glue" that enables a diverse ecosystem to act in a unified manner? Can living elements within an ecosystem be considered to posses a common 'purpose'?

5.2 Purposefulness

Purposefulness in nature is the idea that every organism, system or process in nature has a purpose, rather than being considered a mere random aggregate of molecules and cells. Although still controversial, the idea of purposefulness in nature is in some sense derivative from the idea of nature's self-maintenance and self-realization and therefore cannot be ignored. Some of the major criticisms of the Gaia hypothesis, when it was first acknowledged, were its teleological implications. Being part of the system of Gaia, all living organisms may be considered to possess the same purpose - mainly that of maintaining their own existence and that of the bigger system of life of which they are part. The fact that most living processes are able to achieve their purpose is because they are under control, but they could not be controlled in the first place unless they had a purpose to achieve. Control serves to assure that life processes achieve their pre-set purpose (Goldsmith, 1998: 169).

Others go as far as claiming that purpose is, in fact, synonymous with existence in living organisms;

> Organisms embody their purpose in themselves; for an organism to exist is to possess self-interest. Unlike the machine, which can exist as a durable material structure independently of fulfilling the purpose for which it is made, the existence of the organism coincides with its purpose, for its purpose is to exist. Its purpose is not, like that of the machine, contingent to its existence. It is not defined relative to some external designer who may or may not exist. Since the existence and the purpose of the organism coincide, interest enters the world, ontologically speaking, in the shape of the living system (Mathews, 1991: 101).

Since the idea of purpose in nature moves far beyond the realm of science and ecology into a realm of religion and philosophy, it may be useful to turn to philosophy in order to investigate the origin of the idea of purpose in nature.

Aristotle seems to be the first philosopher who acknowledged the inherent directedness in nature: "Nature is a cause that operates for a purpose" (Aristotle, quoted in Wattles, 2006: 449). Aristotle also found goal-directed motion in the elements of nature - earth, air, fire, and water; "For example, the natural motion of fire is to rise toward its place above the earth, to the outermost sphere of the heavens. The natural place of earth, or earthy things as such, is the center of the earth. Because these elements have their tendencies in themselves, nature is a principle of change internal to things" (Wattles, 2006: 450). Later on, Kant himself admitted that the human mind cannot grasp living things without using the concept of purpose, and then went on to further acknowledge that we can only assign purpose to natural things if the world at large is a product of intelligent cause (Wattles, 2006: 452-3). Hegel also affirms, according to Wattles, that "life must be grasped as self-maintaining and that self-maintenance is implicitly teleological" (p.455) although Hegel assumed that, in the end, "teleology is not an affair of intelligent design but rather, that living systems themselves show an internal teleology of their own, which comes to self-realization in human beings" (p.457). Turning to more recent philosophers, Wattles mentions Rolston as a philosopher who introduced the concept of value into teleology: "to speak of a *telos* or goal implies seeking or striving of some kind, which in turn implies a value in some sense. Hence the *teloi* are the values sought - and realized - in the diverse stages of life" (p.458).

It is apparent, then, that teleology has been acknowledged as significant to the definition of nature throughout the history of philosophy, albeit somewhat less accepted in scientific circles because it is nearly impossible to prove on scientific terms. But with theories such as the Gaia hypothesis gaining more acceptance it may become easier to eventually prove that the universe does possess an inherent directionality.

Assuming that purpose is inherent to living organisms, the interdependence between organisms and their environment as one interrelated ecosystem, entails that organisms are not only 'responsible' for their own self-maintenance, but also for the maintenance of the environment of which they are part and which sustains them. It is a fact that as organisms become more and more coordinated in their actions, they are able not only to support the maintenance of their environment more effectively but also to strengthen their own coherence as a result (Goldsmith, 1998: 217). An example to illustrate this is the interdependence that exists between a tree and the soil from which it grew. The nutrients in the soil enable a tree to grow; as the tree grows and becomes part of the cycle of the seasons, it can begin to contribute back to the soil by shedding its leaves in winter, thereby restoring nutrients to the ground. The cycle continues as the soil, which is now richer with nutrients, can continue to support the growth of the tree. The richer the soil is with nutrients - the more it can contribute not only to its own development but to the development of the tree and the other plants which it supports. This illustrates how individual self-interest corresponds with collective interest within an ecosystem. As an organism grows, the definition of its organization grows accordingly, and its correspondence with the purpose and maintenance of its wider environment grows as well. In the same way, it may be concluded that the larger the amount of organisms/nutrients occupying the same environment, the larger the capacity of that environment, as a unified ecosystem, to achieve its purpose, and the larger the capacity of each one of its occupying organisms to achieve their own autonomous purpose accordingly (Capra, 1982: 317).

The idea of purposefulness can inform architectural design by considering, for example, how individual 'purposes' of different types of users of the architectural environment can support the 'purpose' of the natural processes they interact with. In other words, how may correspondence between functional activities and natural processes be supported by the design of the built environment? This idea will be further explored in the third and forth sections of this thesis.

Interdependence between part and whole through a correlation in purposes (i.e. to exist as a unified system) reveals that living organisms are able to maintain certain conditions which enable them to sustain themselves as part of larger ecosystems. But how do living organisms and ecosystems manage to maintain themselves as coherent wholes?
The ecological ability of self-maintenance and self-creation will be explored in the following paragraph through the principle of *autopoiesis*.

5.3 Autopoiesis

Living organisms' ability to self-organize (i.e. to generate and maintain their own self-organization) is a quality which, to some extent, distinguishes them as complete entities, in relation to their environments. Being a self-organizing system means that

> its order in structure and function is not imposed by the environment but is established by the system itself. Self-organizing systems exhibit a certain degree of autonomy; for example, they tend to establish their size according to internal principles of organization, independent of environmental influences. This does not mean that living systems are isolated from their environment; on the contrary, they interact with it continually, but this interaction does not determine their organization (Capra, 1982: 290).

The ability of living systems to self-organize ensures that they are not entirely dependent on external conditions for their survival, and can still maintain autonomy even when the external environment is undergoing a major disturbance. This self-organizing capacity of living systems is also known by the term 'autopoiesis,' which is derived from Greek; 'auto' meaning 'self', and 'poiesis' meaning 'production' or 'creation.' The concept of autopoiesis was developed by the biologists Maturana and Varela in the 1970s and describes the autonomous capacity of living systems to self-produce their own organization without having to rely on any external forces for their survival. For this reason only, living systems are regarded to possess a certain degree of autonomy in relation to the environment, and this autonomy is expressed in their internal unity as an organized self-realizing, 'autopoietic' system. An autopoietic system is described as

> a machine organized (defined as a unity) as a network of processes of production (transformation and destruction) of components that produces the components which: (1) through their interactions and transformations continuously regenerate and realize the network of processes (relations) that produced them; and (2) constitute it (the machine) as a concrete unity in the space in which they (the components) exist by specifying the topological domain of its realization as such a network (Maturana & Varela, 1973: 78-9).

Although living systems function in an autopoietic manner most of them cannot actually survive in complete isolation from their external environments. If they remain "closed" to outside forces, they will end up degrading into chaos. According to the second law of thermodynamics, the entropy (level of disorder) of an isolated system will tend to increase over time. Open systems evade the degenerative effects of the second law by exporting entropy into their environment. In this way, although the total entropy of the universe continually rises, open systems maintain their coherence and order, and may even increase it (Prigogine, as explained in Davis, 1989: 85).

It may be assumed, then, that the basic capacity of living systems to maintain internal coherence - a process otherwise known as 'autopoiesis' - does not necessarily imply that they are completely isolated from the outside. This can be exemplified by the capacity of the human body to sustain more-or-less stable body temperature even in extreme weather conditions, without necessarily implying that the body is not influenced at all (or in other ways) by the external conditions. When an organism seeks to grow and develop it must, at some point, compromise some aspects of its constancy and stability in order to evolve. Completely closed, isolated systems are limited in their ability to develop, while open systems, which are in constant interaction with their environment, are capable of tremendously increasing their complexity by abandoning structural stability in favour of flexibility and open-ended evolution (Capra, 1982: 439).

Openness and flexibility are essential not only for individual growth but also for collective growth. Organisms are individual 'wholes' in relation to their environment and they are also part of a bigger ecosystem. An organism's own existence depends both on its capacity to withstand environmental pressures as well as on its capacity to fit into its environment (Wilber, 1996: 21). Wilber refers to these complementary phenomena as "agency" and "communion." Communion between agents is essential for the overall coherence and maintenance of the ecosystem. It means that agents are capable of filling one another's niches when necessary. The autonomy of each agent is therefore temporary, until a need arises for the agents to adapt and overlap in function. This ability to adapt is an essential part of a living systems' resilience. Agents in a living system learn about one another through the information and energy that they constantly exchange. Their ongoing interaction is essential in order to maintain individual 'autonomous' coherence in relation to the other agents, but this 'autonomy' is dynamic and relational.

Communion between agents implies the importance of diversity, as Capra explains;

> A diverse ecosystem will be resilient, because it contains many species with overlapping ecological functions that can partially replace one another. When a particular species is destroyed by a severe disturbance so that a link in the network is broken, a diverse community will be able to survive and reorganize itself, because other links in the network can at least partially fulfil the function of the destroyed species. In other words, the more complex the network is, the more complex its pattern of interconnections, the more resilient it will be (Capra, 1997: 295).

The interdependence between agents in an ecosystem and their openness to the environment enable them to constantly exchange energy and information and work together as a unified, autopoietic system.

As a conclusion, it can be assumed that autopoiesis exists within autonomous living organisms as well as within the larger ecosystem of which they form a part. While autopoiesis denotes a certain degree of autonomy, it also implies openness, since without a certain degree of openness, a living system risks degrading into a chaotic state.

The idea of autopoiesis can inform architecture by aiming to design 'autopoietic' architectural environments, that integrate all their interacting users and composing processes into one self-sustaining unity. The different ways in which 'autopoietic' architectural environments may be encouraged will be explored in the third and forth sections of this thesis.

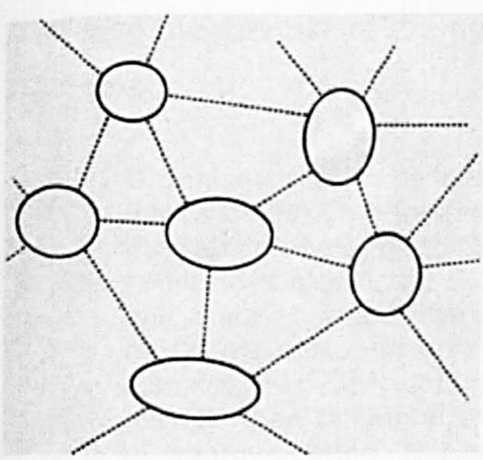
The next chapter will begin to investigate the relational dynamics between the different agents within an ecosystem.

6. The principle of Relational dynamics

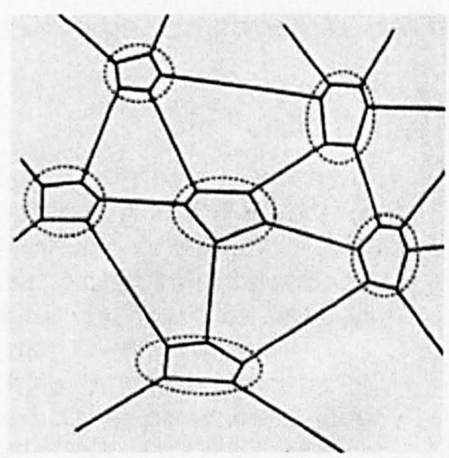
The previous chapter examined the relation between the part and the whole in an ecosystem and how this relation influences the formation and maintenance of the ecosystem. The following discussion will focus on the type of relations that exist between the 'parts' or 'agents' themselves according to three principles: (1)Positional value (2)Feedback mechanisms (3)Homeostasis.

6.1 Positional Value

The nature of relations between agents in an ecosystem is significant both for the formation of the ecosystem as a whole, as well as for the identity of the agents themselves. This is due to the fact that components of an ecosystem do not exist in complete isolation from their environment (just as the ecosystem as a whole is not completely isolated from its environment) and they constantly interact with one another in order to exchange energy and information. Even the smallest structural elements, such as atoms, are in themselves patterns of relationships rather than concrete, isolated substances (Capra, 1997: 37).



Elements with relationships between them



Elements are patterns of relationships themselves

(Illustration from: Capra, 1997: 37)

Recognizing the significance of interdependence between agents in ecological systems shifts the focus away from studying singular elements into studying relationships. In post-genome biology, for example, researchers move beyond the *structural* studies of isolated genomes into the *functional* studies of their interactions. Functional studies of genomes can only be revealed by looking at the wider context in which the genome acts, thus; studying the dynamic interaction of one genome with other cell components (Barabasi, 2002: 242). Shifting the focus of study from concrete components to relationships stems from a deeper understanding, in various scientific disciplines, that the environment in which components are studied is not fixed but dynamic, and that its dynamism is a result of constant interactions between various forces;

> Each agent finds itself in an environment produced by its interactions with the other agents in the system. It is constantly acting and reacting to what the other agents are doing. And because of that, essentially nothing in its environment is fixed (Waldrop, 1992: 145).

Waldrop describes a dynamic environment which is a result of agents' interactions with one another, but it can be argued that not only the identity of an environment is the result of interactions, but that also the identity of the agents or organisms themselves is relational;

> Organisms are knots in the field of intrinsic relations. An intrinsic relation between two things A and B is such that the relation belongs to the definitions or basic constitutions of A and B, so that without the relation, A and B are no longer the same things. The total field model dissolves not only the man-in-environment concept, but every compact thing-in-milieu concept - except when talking at a superficial or preliminary level of communication (Naess, 1989: 28).

Naess defines a 'relational field' in which agents within the system are defined by their relation to one another, so that if one agent changed its position - its identity is changed as well. In a similar manner, Mathews refers to a 'positional value' of elements in a system according to which it is the position of an element within a system, rather than the element itself, as an object, which constitute the system, and these positional values are inherently relational - they cannot be defined independently of the system within which they are located (Mathews, 1991: 114). The significance of an agent's position within a system, then, is highly relevant not only for the definition of the agent in itself but for the definition of the entire system, since each agent influences the system differently, according to its positional value and its interaction with other agents. It is acknowledged that, control in ecosystems and other types of complex systems, is dispersed rather than imposed from above by an external source. This is considered to be one of the defining characteristics of complex systems: "If there is to be any coherent behaviour in the system, it has to arise from competition and cooperation among the agents themselves" (Waldrop, 1992: 145). It can be assumed then, that a change in position for one of the agents may trigger, in some instances, a chain of events which can have significant consequences for the system as a whole. The relative position of the agent within the system can generally suggest what its range of influence may be on the entire system. This is exactly what Lovelock refers to when he describes one of Gaia's three principle characteristics:

> Gaia has vital organs at the core, as well as expendable or redundant ones mainly on the periphery. What we do to our planet may depend greatly on *where* we do it (Lovelock, 1979: 119. my Italics).

The above quotation suggests that the relative positional value of certain elements within an ecosystem can indicate their probable range of influence on the system of which they are a part.

The idea of positional value can inform architectural design by considering the relative range of influence that different users may have on the architectural environment, throughout their interaction with it. Similar to the way in which different organisms can influence and determine the formation of their ecosystem habitat, different types of users can be considered to generate potentially different impacts on their architectural environment. The idea of positional value and its' significance to architecture will be explored further in the third and forth sections of this thesis.

The ability of agents to influence their environments through their dynamic interactions with one another is best explained through the idea of *feedback*.

6.2 Feedback Mechanisms

One of the characteristic properties of all living organisms, from the smallest to the largest, is their capacity to develop without disrupting their original stable organisation. This is mainly achieved by setting a goal and then striving to achieve it through the cybernetic process of trial and error (Lovelock, 1979: 45). It is therefore the cooperative feedback nature of living system, manifested through interdependent loops of reaction, which help to keep the system in tact.

The phenomenon of feedback is possible in living systems due to their nonlinear organization. Thus, an influence, or message, "may travel along a cyclical path, which may become a feedback loop. The concept of feedback is therefore intimately connected with the network pattern" (Capra, 1997: 82). The loop becomes possible when there is constant flow, circulation, return, backtrack, and movement around. Flows and events in a network influence not only

other events but might also return and effect the initial event, and for this reason is considered to be circular. In this way, a feedback loop occurs - a given state of the system reacts on itself to produce a further effect.
Living systems need feedback loops for two main reasons:

(1) To bring the system back into balance.
(2) To drive the system into a different state.

In the first instance, a feedback may be described as *negative*, and in second one as *positive* (Heylighen, 1997: 10). Feedback is said to be negative (balancing) if the reaction is opposite to the initial action, that is, if change is suppressed or counteracted, rather than reinforced. Negative feedback stabilizes the system, by bringing deviations back to their original state (Heylighen, 1997: 10). Usually, whenever there is a deviation from the norm, due to outside influences, negative feedback loops tend to bring the system back into balance. In a large ecosystem, negative feedback loops can be exemplified through the concept of recycling; Ecosystems do not produce waste because what is waste for one organism immediately becomes nutrient for another. In this way, constant feedback loops between organisms maintain a balanced, waste-free ecosystem. Another example of negative feedback can be illustrated by the correlation between populations of birds and caterpillars;

> As the number of caterpillars in the population increases, so does the number of birds which feed on them; but as the number of birds increases, the population of caterpillars is diminished. The bird-caterpillar system is in this respect self-regulatory: it can regulate the value of its state variables without the aid of external controls or constraints (Mathews, 1991: 95).

Positive feedback, on the other hand, makes deviations grow in a runaway, explosive manner. It leads to accelerated development, resulting in a radically different configuration. Feedback is said to be positive if the recurrent influence reinforces or amplifies the initial change. In other words, if change takes place in a particular direction, the reaction being fed back takes place in that same direction (Heylighen, 1997: 10).

One example of positive feedback is the phenomenon of eutrophication in a pond ecosystem. Eutrophication is a process whereby water bodies receive excess nutrients. As the water become eutrophied, organisms begin to die, adding to the existing organic matter suspended in the water; this further eutrophication in turn causes more organisms to die, which further eutrophies the water, and so on. Positive feedback mechanisms are involved in the processes of growth and death – the major changes to which organic systems are subject (Mathews, 1991: 95).

Another example of positive feedback is the 'runaway greenhouse effect' – where rises in temperature, caused by global warming, affect natural sources and sinks of CO_2. These, in turn, further increase CO_2 levels and trigger a self-perpetuating process. Oceans, for example, can absorb CO_2, and, together with terrestrial plants, absorb half of the global CO_2 emissions. But as ocean temperatures rise, this ability decreases, which increases atmospheric CO_2, and raises temperatures still further. Other mechanisms that increase CO_2 gases as a result of rising temperatures include evaporation from the oceans, which add water vapour to the atmosphere; and the thawing of the permafrost layer, which releases methane (Sassi, 2006: 201).

It is the interplay between positive and negative feedback loops which keeps the system intact and also allows it to evolve. While negative feedback keeps the system in a point of equilibrium despite unpredictable changes, positive feedback propels the system onwards. Without negative feedback, systems would end up in chaos and die, and without positive feedback, systems would not be able to

'take a leap' forward and change their structural configuration when such is needed. It is mainly negative feedback, though, which is constantly activated in living systems in order for them to maintain their stability in the face of constant environmental threats.
The notion of the feedback loop, in natural as well as artificial systems, was studied and developed by the cybernetics scientists. Cybernetics, a science developed in the late 1940's, had focused on understanding the principles of organization in complex systems - how systems[6] use information and control actions to steer toward and maintain their goals, while counteracting various disturbances. Cybernetics is concerned with those properties of systems that are independent of their concrete material or components. This allows it to describe physically very different systems with the same concepts, and to look for similarities in form and relations between them (Hayles, 1996).
Cybernetic studies revealed, among other things, that the time constant associated with feedback loops is highly significant for their success in regulating a system in the desired direction. The regulation of oxygen on earth, for example, has a time constant measured in thousands of years. Such slow processes give the least warning of undesirable trends and make it increasingly difficult to realize when something in the earth's regulation mechanism is not well; "by the time an action is taken, inertial drag will bring things to a worst state before an equally slow improvement can set in" (Lovelock, 1979: 119). Lovelock explains how human actions are considered to be an inseparable part of Gaia's regulation mechanism. The main difference between natural processes and human-initiated processes is that human processes, which are

[6] A system in the context of Cybernetics and Systems theories is defined as "a group of interacting components that conserves some identifiable set of relations with the sum of the components plus their relations (i.e., the system itself) conserving some identifiable set of relations to other entities (including other systems)" (Laszlo, 1997: 8).

driven by technologies that release increasing amounts of energy into the world, provide humans with a similarly increased capacity to channel and process information (Lovelock, 1979: 118). If our skills in handling information develop faster than our capacity to produce more energy, then we may be able to control the processes that we create. But if our capacity for response does not match up with the consequences that our technologies create for the world, then the feedback loops initiated by human technologies become positive loops (i.e. they drive the world-system away from equilibrium);

> An increase of power input to a system may enhance the loop gain and so assist in the maintenance of stability, but if the response is too slow, increasing the power input could be the recipe for a whole series of cybernetic disasters... A key factor in our relationship with the rest of the world and with each other is our capacity to make the correct response in time (Lovelock, 1979: 119).

Lovelock argues that humans 'release' into the world technological processes which influence Gaia's natural feedback mechanism in ways which are not yet completely understood, due to their fast-pace, which does not correlate with nature's much slower pace. It is therefore human responsibility to figure out how to utilize their technological processes in a way which will match and enhance the Earth's regulative processes.

In the same way, architecture can be regarded as one of human 'creations' which should be integrated with the larger regulative, feedback processes of the earth instead of interfering with them. The idea of feedback can therefore inform architectural design by considering how negative and positive feedback mechanisms can be integrated into the design of the built environment in a way that will enable the regulation of users' actions in relation to wider natural processes. This idea will be further explored in the third and forth sections of this thesis.

When introducing feedback relations into a system, it is important to understand the purpose to which feedback relations are needed in the first place. Feedback mechanisms enable ecological and other complex systems to self-regulate their agents' actions with minimum disruption to the overall system maintenance. For this reason, it is important to introduce the idea of equilibrium or *homeostasis*.

6.3 Homeostasis

Homeostasis can be defined as the ability of an ecosystem to maintain stable conditions for its 'autopoiesis' (self-creation) to continue to manifest itself. The process of maintaining homeostasis within a living system is a dynamic process of coordination through competition and cooperation among the different agents and forces that a system encounters, and is therefore considered to be an essential part of a living system's 'relational dynamics.' Without the tendency for homeostasis living systems could easily degrade into chaos as soon as an internal or external disturbance interfered with their on-going self-maintenance (Hayles, 1997). The fact is, as has been revealed in the discussion so far, that most living systems are inherently dynamic systems. Their dynamism is one of the main characteristics of their liveliness and self-creation. Living systems are dynamic because they are autopoietic systems. This means that they constantly self-produce their own organisation and therefore can never remain completely static. Their obligation to their autopoietic nature also means that they need to keep their control mechanisms alert in order to withstand external as well as internal changes (Maturana & Varela, 1973: 80).
It therefore may be understood, that although living systems are also geared toward maintaining their homeostasis and avoiding disruptive change, change occurs, "not because it is desirable per se,

but because in certain conditions it is judged to be necessary, in order to avoid predictably larger and more disruptive changes" (Goldsmith, 1998: 137). The quality of dynamics, then, is essential in living systems for long-term survival as well as for evading the devastating effects of the second law of thermodynamics.

> Only if creative play is allowed, if the mechanism can adapt freely to changing messages, can homeostasis be maintained, even temporarily, in the face of constant entropic pressure toward degradation (Hayles, 1997: 13).

It becomes clear that stillness is not really possible in the living world. The 'best' that systems can aim for is a constant coordination towards homeostasis and autopoiesis. In fact, by constantly exporting energy into the environment, it is the very dynamism of living systems which allows them to maintain their homeostasis. As a summary, it can be assumed that living systems have two main choices:

1. They can remain still and end up degrading into chaos, as the second law of thermodynamics suggests.
2. They can maintain a certain degree of activity, by importing and exporting energy, and ensure stability for the long run.

It is now easily apparent that the second choice is a better trade-off. While some systems may choose to deploy a low degree of activity (apparent more frequently in ecosystems which have already reached their peak development and are now mainly 'interested' in maintaining their status-quo rather than continue to develop), other, usually less-mature systems, are more highly active. It is then evident that the more a system's variables are kept fluctuating, the greater its ability to remain flexible and adapt to changing conditions. The more adaptive a system is, the greater its ability to remain stable (Capra, 1997: 294). Taking into account that all living systems are in constant change – adaptability is an essential quality

to have in this kind of environment. An absence of adaptive qualities in an organism could, in fact, damage it by letting external as well as internal changes disrupt its proper development.
An additional trait which is important for maintaining stability in large ecosystems is diversity;

> The theory of Gaia has developed to the stage where it can now be demonstrated, with the aid of numerical models and computers, that a diverse chain of predators and prey is a more stable and stronger ecosystem than a single self-contained species, or a small group of very limited mix. An essential feature of these new Gaian models is the tight coupling between the organisms and their material environment. If these findings are true, it seems likely that the biosphere diversified rapidly as it evolved (Lovelock, 1979: 21).

Lovelock suggests not only that a diverse ecosystem is likely to be more stable, but that the overall stability of the system leads to a tendency to grow (and diversify). These explanations entail that through constant interaction and feedback ecosystems tend to 'know' what is best for them and to develop in that direction.
An example may be the regeneration of the Indonesian island of Krakatoa. The island experienced a major eruption in 1883, when the established stable homeostasis of the previous climax forest ecosystem was destroyed and all life was eliminated from the island. In the following years, the island went through a sequence of ecological changes in which successive groups of new plant and animal species followed one another, leading to increased biodiversity and eventually leading to a re-establishment of the ecosystem. In 1983 it has been recorded that the island reached its climax community with eight hundred different species. This number has now been homeostatic for some time, with the introduction of new species rapidly leading to elimination of old ones. This example illustrates how an ecosystem may be able to regenerate itself and

develop until it reaches its climax condition, and is then able to maintain this climax through homeostatic interactions.

The idea of homeostasis can inform architectural design by designing possibilities for users of the architectural system to regulate their actions within the environment in relation to natural processes, in a way that will lead to overall stability and homeostasis within the wider environment. This will be further explored in the third and forth sections of this thesis.

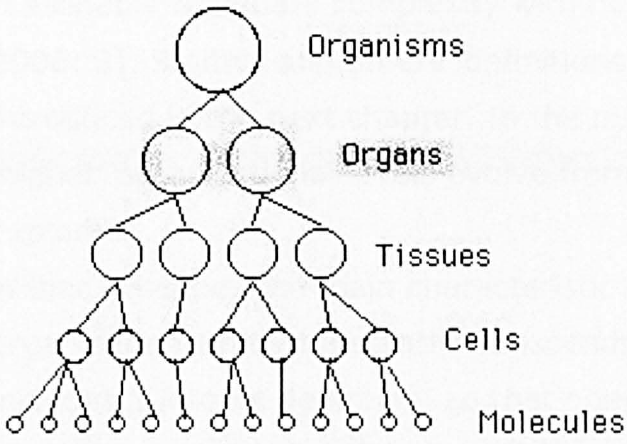
As a summary, it can be maintained that the nature of relations between agents within a system determines to a large extent the capacity of both the agents as well as the bigger system to maintain their stability. Negative and positive feedback loops enable a system to regulate itself - to ensure homeostasis as well as be able to evolve. It has also been mentioned that feedback mechanisms must be correlated in pace in order to achieve stability within a system. It is therefore logical to assume that focusing on *relations* rather than on the agents as isolated individuals can teach us more about the behaviour and regulation of the system as a whole. While negative feedback relations mainly lead to homeostatic conditions, positive feedback relations can be introduced in order to encourage emergence of new organisational levels within a system. The idea of emergence and how it occurs in natural systems will be explored in the following chapter.

7. The principle of Emergence

The discussion in the following chapter will explore one of the most distinctive and intriguing characteristic of living systems and this is their capacity to evolve by producing new levels of organisation, a phenomenon otherwise known as: *emergence*. The discussion about emergence will proceed according to three principles; (1)Holarchic organization (2)Increasing complexity, and (3)Self-transcendence

7.1 Holarchic Organization

Natural living systems display a certain type of organisation which characterises their unique ability to maintain their autonomy and homeostasis on the one hand and be able to constantly adapt, change and evolve on the other. This unique organisation is best described by the idea of *holarchy*. Holarchy is a term first coined by Arthur Koestler (1967) and refers to a special type of hierarchical organization composed of individual holons. Holons are components best described as being both individual wholes as well as parts of a bigger system. Observed from 'lower' levels - a holon will look as a whole, while observed from 'higher' levels - it will look as a part.



A holarchic structure (Funch, 1995)

Holarchies, unlike hierarchies, are formed gradually from the bottom upwards, such that the interactions between holons at a 'low' level define the next 'higher' level and so on. For example, atoms develop chemical bonds with one another to create molecules which can be described as higher-order holons (Smith, 2006: 3).
The definition of levels in a holarchy in terms of 'lower' and 'higher' refers to their position in relation to other levels within the holarchy. Smith identifies two main types of criteria which help to 'rank' levels in a holarchy; one is the manifestation of new properties in a holon not found in lower-level holons. For example, molecules have properties which are not exhibited by atoms, and all cells have properties not exhibited by molecules, so by this criterion, cells are higher than molecules, which in turn are higher than atoms. A second criterion is an asymmetric relationship between holons, where a lower holon is necessary for the existence of the higher, while the higher is not necessary for the lower. So, cells are higher than molecules since molecules are necessary for the existence of cells but not vice-versa (Smith, 2006: 1). Smith then introduces a third criterion for identifying holarchic status, and this is the degree of complexity of the holon. He explains that "it is widely accepted

that as life has evolved, it has become more complex, so it's quite reasonable to equate complexity with holarchical status" (Smith, 2006: 3). Smith's and others' definitions of complexity will be introduced in the next chapter. In the mean time, the way in which 'higher' organisational levels evolve from 'lower' ones will be further explored.

Wilber describes the main characteristic of holarchy as an organisation which constantly transcends what went on before and includes it into its definition, so that none of the qualities of the previous levels are lost in the process;

> The point is that since all holons are whole/parts, the wholeness *transcends* but the parts are *included*. In this transcendence, heaps are converted into wholes; in the inclusion, the parts are equally embraced and cherished, linked in a commonality and a shared space that relieves each of the burden of being a fragment (Wilber, 1996: 30).

The idea of transcendence and inclusion, which Wilber describes as one of the main defining characteristics in the formation of holarchies, is argued by some to be a quality which is not manifested at all times. Smith argues that properties of lower holons are not necessarily preserved as the system becomes more complex. In fact, the new, higher properties are realised *at the expense* of some of the former, lower properties.

> When cells associate into tissues, they gain new properties. Thus some neurons in the brain can respond to complex patterns in the organism's environment, something no autonomous cell could do. But they lose the ability to move around and to respond in certain ways to their immediate physical environment, properties of most autonomous cells (Smith, 2006: 7).

The difference between the process that Wilber describes (transcend and include) and the process that Smith describes (transcend and exclude) is, according to Smith, a difference between two separate processes, both of which occur in living systems. While the second process (that of transcend and exclude) describes most holarchic formation processes, the first process (transcend and include) only refers to a very specific type of process, which characterises the formation of a new, *autonomous* level of organisation, which can generally exist independent of the holarchy and is able to reproduce itself. The difference between the two processes of transcendence will be further explored in the chapter about self-transcendence.

The idea of holarchy can inform architectural design by considering the possibilities in which architecture may be able to evolve and form new organisational levels over time. This may be possible by introducing positive feedback mechanisms into the architectural system which may enable evolution within the built environment. This idea will be further explored in the third and forth sections of this thesis.

The next paragraph will examine how 'higher' levels within a holarchy may exhibit an increase in complexity in comparison with 'lower' levels.

7.2 Increasing Complexity

The idea that life becomes more complex as it evolves is an idea which makes sense on an intuitive level, but which is more difficult to prove scientifically. Evolutionary theory, since Darwinian times, observed that simple systems existed in earlier times (elementary particles, atoms, molecules, unicellular organisms) while more and more complex systems appeared in later stages (multicellular organisms, vertebrates, mammals, human beings). Many theories offering new methods for modelling complex systems have emerged only in recent decades, such as: cybernetics,

information theory, general systems theory, complex adaptive systems, etc. and slowly enable to understand better how complexity might be measured (Heylighen, 1996: 17).
According to Heylighen, there are two distinct characteristics which can help to evaluate the degree of complexity a system possesses, and these are: distinction and connection.

> Distinction corresponds to variety, to heterogeneity, to the fact that different parts of the complex behave differently. Connection corresponds to constraint, to redundancy, to the fact that different parts are not independent, but that the knowledge of one part allows the determination of features of other parts... A system would be more complex if more parts could be distinguished, and if more connections between them existed (Heylighen, 1996: 19).

In a somewhat similar manner, Smith defines complexity in individual holons as "the number of degrees of freedom it has, which is to say, the number of distinct states it is possible to exist in" (Smith, 2006: 4). He then gives an example of an amino acid molecule, which can exist in various different states and explains that this variety of degrees of freedom in amino acid molecules results "directly from the fact that it contains numerous atoms with hetarchical relationships to one another... the relationships between the atoms can be altered when the relative position of the atoms to each other changes" (Smith, 2006: 4). Smith's example corresponds with Heylighen definition of complexity as the existence of distinction and connection. A variety of atoms (oxygen, carbon, etc.) and a changing connection between them allows the amino acid molecule to exhibit a higher degree of freedom (various states of existence), which can be regarded as a higher complexity, in comparison with an individual atom – a hydrogen atom, for example – which can only exist in two states: as neutral or positively charged (Smith, 2006: 4). This implies that holons at a higher level will tend to exhibit a higher degree of complexity, since the possible synthesis

between their components is higher, and therefore, their possible degrees of freedom (or distinct existence), is also higher.
The increase in complexity at higher levels is also due to another phenomenon, which can be described as an increasing opening-up of possibilities which encourage growth in complexity. The fact is that the higher level components, most often, enable not only interactions between the components on their own level, but open-up new possibilities for interactions between components at different levels as well.

> [Thus] the atoms in complex molecules not only interact directly with their immediate neighbours, but indirectly with very distant atoms. This further increases the complexity of the large molecules, that is, adds to the total number of possible states in which it can exist (Smith, 2006: 6).

This phenomenon is well evident in ecological systems, which tend to become more complex over time. As the number of species increases, the number of linkages and dependencies between them increases as well which opens up more niches for new species to occupy (Heylighen, 1996: 25). A metaphor which clarifies this type of mechanism is that of an infinite jigsaw puzzle;

> Every system that is selected can be seen as a piece of the puzzle that has found a place where it fits, locking in with the neighbouring pieces. However, every newly added piece will add a segment to the puzzle's outward border, where further pieces may find a place to fit. The more pieces are added to the puzzle, the larger the border becomes, and the more opportunities there are for further pieces to be added. Thus, every instance of "fit", or niche filled, increases the number of available niches, leading to a run-away, positive feedback process of growing complexity (Heylighen, 1996: 25).

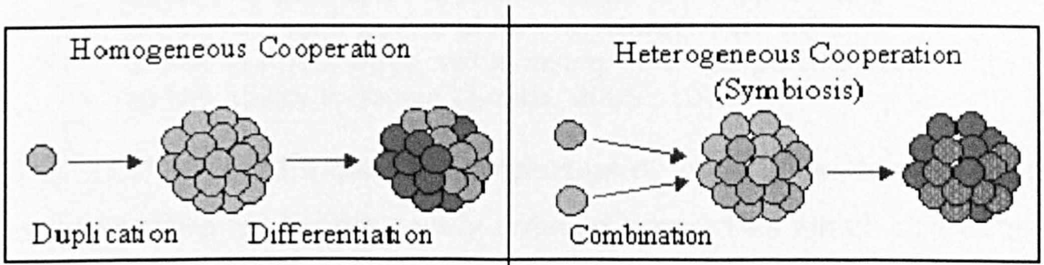
It seems reasonable, then, that living systems become more complex over time because this increases their chances of survival. After all, it has been observed in previous chapters that the more a system is diverse and adaptable, the better its chances to withstand environmental pressures and endure. Systems evolve in order to fit better into their environments, which are usually more complex than the system itself (mainly because they contain a larger variety of interacting species). So a system must continuously develop in order to merely maintain its fitness relative to the systems it co-evolves with. This fact in itself explains why open systems (which constantly exchange information and energy) tend to increase their complexity over time. "The net result is that many evolutionary systems that are in direct interaction with each other will tend to grow more complex, and this with an increasing speed" (Heylighen, 1996: 28). Some scientists object to the idea that evolution necessarily progresses in the direction of increased complexity. One of the main criticisms, formulated primarily by Stephen Jay-Gould, argues that the increase in complexity implies that there is a preferred direction for evolution, and this contradict observations which indicate that evolution is a largely chaotic, unpredictable and contingent series of events, where small fluctuations may lead to major catastrophes that change the future course of development (Heylighen, 1996: 30). Heylighen explains that the two notions do not contradict one another. He gives an example of a rock rolling down a steep mountain; while it cannot be predicted at which point the rock will end up, it is certain that the final position will be lower than the initial position at the top. In the same way, although evolution is largely unpredictable and can turn in an infinite number of directions, it is most likely that it will prefer a direction in which complexity increases. Heylighen notes that it is possible, although rare, that some systems evolve towards a simpler organization, and this is mostly apparent is situations where a system enters a simpler environment and wishes to adapt to it. Still, these are unusual examples which "go against the general trend of environments becoming more complex" (Heylighen, 1996: 33).

The idea of increasing complexity can inform architectural design as a way of recognising whether or not emergence occurred within the built environment over time. The characteristics of an increase in complexity, which were described as increased distinction and increased connectivity may be able to inform the evaluation of 'evolution' within architectural environments. This idea will be further explored in the third and forth sections of this thesis.

The next paragraph will examine the different ways in which evolutionary self-transcendence may occur within living systems.

7.3 Self-Transcendence

Self-transcendence is the process by which a system transcends its own structure to result in a new, usually more complex organisation. Self-transcendence, otherwise referred to as 'meta-system transition,' usually occurs as a result of one of the following processes; (1)homogeneous cooperation; or (2)heterogeneous cooperation (Sharov, 1998).



(1) Homogeneous cooperation (2) Heterogeneous cooperation

Homogeneous cooperation is a process where one system duplicates itself and then differentiates to create a new type of a more complex system. An example of a homogeneous cooperation is embryonic development of most multicellular organisms. Cells are first

multiplied and then differentiated into various cell types from which an organism is eventually developed (Sharov, 1998).
Heterogeneous processes describe a symbiotic cooperation between several non-similar organisms, which can result in the creation of a new system. A classic example is the lichen, which is a symbiotic joining of two different organisms - an alga and a fungus - they support each other by producing substances the other partner is incapable of producing, and the result is an emergence of a new organism, which is the lichen (Heylighen, 1996: 23).
The process of self-transcendence, whether it occurs through homogeneous or heterogeneous cooperation, is a process which leads to a new structural organisation, higher than the previous level components that created it. The new, higher level which has been created includes the lower level components within it, but these lower level components, in most cases, no longer embody the same characteristics that they had in the previous, lower level. In most cases, something has to be 'given up' in order for the new, emergent level to become possible.

> When various types of molecules are created, new properties emerge, but older properties are lost. Thus by becoming part of an amino acid, an atom gains new properties such as the ability to interact with other atoms in novel ways, while losing other properties such as the ability to ionize (Smith, 2006: 10).

The 'loss' of some individual properties of lower level components is compensated for by the newly created properties which characterise the new level. At the new, higher level, components usually have a larger variety of components to interact with, both on their own level as well as with components in adjacent levels. An additional advantage of higher levels is that their components, although more numerous, release less energy in total because they are bounded to each other; "In an environment that is not too rich in energy, bound configurations are intrinsically more stable than configurations consisting of freely moving particles, and thus will be naturally selected. Since the second law of thermodynamics implies a natural tendency of energy to dissipate, it should not surprise us that the history of the physical universe since the Big Bang is characterised by the emergence of ever more numerous bonds between particles" (Heylighen, 1996: 24). Higher levels, then, offer more opportunities for interactions between components, although these interactions usually result in weaker bonds. For example, it requires much more energy to break up an atom than to break up a molecule, and it is easier to disperse a herd of animals than to separate the cells that make up their bodies. This generally means that only after the lower, strong bonds are secure, and stability is ensured, that the next, higher and often weaker bonds will be able to form;

> The strong linkages will produce tightly bound assemblies or systems, in which internal variation has been strictly constrained. These systems will continue to undergo free external variations and appear in different combinations, until they discover a combination that is itself bound, i.e. in which the different components have established a set of (weakly) fit connections. This determines a less strongly bound higher order system, which has the more strongly bound systems as parts (Heylighen, 1996: 24).

This type of holarchic, self-transcendent organisation ensures stability for the whole system while also enabling the components to continue to interact until they reach an 'appropriate' type of interaction which they wish to preserve and as a result – are able to evolve to the next level without compromising the stability of the lower levels.

In some exceptional cases, the new emergent level is able to preserve the individual properties of the previous, lower-level components, while, at the same time, manifesting entirely new ones at the higher level. This unusual type of self-transcendence, which has been mentioned in the previous discussion about holarchies as a process of 'transcend and include' is evident in the creation of cells. Unlike molecules, which are created as a result of chemical bonding between atoms, and which do not preserve the individual qualities of atoms, cells contain "not only various kinds of molecules, but also atoms, such as hydrogen and sodium, that exist unbounded to other atoms and thus retain their autonomous properties. Likewise, cells contain amino acids unbounded to other amino acids, proteins not complexed with other proteins, and so on..." (Smith, 2006: 10). Smith identifies three criteria which distinguish holons like cells, which he calls individual or *fundamental holons*, from holons like molecules, which he calls *social holons*. These include: (1)the ability to exist autonomously, outside of higher-order holons; (2)the ability to reproduce; and (3)a unique organisation, in which all the lower-order holons on that level are present in both free and unbounded forms (Smith, 2006: 10).

As a summary, it can be concluded that living systems evolve through the process of self-transcendence, or the creation of new levels of organisation, which generally manifest an increase in complexity. At some point in this process, new levels can emerge which preserve the lower levels' components as autonomous holons within the context of the new level. This process enables a vast increase in complexity, because the complexity of any single level or holon on that level can now exist independently of any other level or holon and interact with holons at any other level (Smith, 2006: 11).

The idea of self-transcendence can inform architectural design by considering how the two different types of self-transcendence - homogeneous and heterogeneous cooperation, may be translated into the built environment and inform possibilities for achieving emergence within that context. This will be explored in the third and forth sections of this thesis.

8. General Conclusions from Section One

The exploration of the ecological principles according to the three chapters reveals the following:

1. *Part/Whole relation* - The relationship between the part/agent in a living system and the whole system is a relation of interdependence. Each agent is autonomous to a degree, but is also dependent on the other agents and the system as a whole for its survival, as long as it remains part of the system. This interdependence among the system's components constitutes the system's autopoiesis as the agents, through their interactions, constantly recreate the system. The autopoietic capacity of the system entails that the purpose of the individual agents corresponds to the purpose of the whole system (i.e. to survive).

2. *Relational Dynamics* - The dynamics among the agents in a living system are relational. This entails that the system maintains overall stability or homeostasis through the feedback relations between its agents. Each agent is constantly influenced by other agents in the system. The position of each agent within the system determines its relative degree of influence on the other agents and on the system as a whole, such that more 'central' and well-connected agents will tend to have a higher degree of significance within the system in comparison to more marginal agents.

3. *Emergence* - The phenomenon of emergence in living systems suggests that new levels of organisation can emerge within the

system, generally manifesting a more complex organisation than previous levels. Therefore, living systems can be considered to develop holarchically, such that their growth is manifested from the bottom upwards. In this way, simpler, 'lower' levels give rise to more complex, 'higher' levels.

The division of the ecological principles into three chapters, which describe ecological systems' organisation according to certain principles; part/whole, relational dynamics, and emergence, proved to be beneficial for explaining the complex and intricate organisation of living systems. The first chapter, focusing on the relation between the part and the whole, helped to describe the very basic relationship that exists within any living system. The second chapter, focusing on the relational dynamics between the components of a living system, helped to illustrate how these inter-relations manifest themselves in an interdependent and flexible manner. And the third chapter, focusing on the phenomena of emergence in living systems, helped to illustrate how the holarchic organisation of living systems enables them to grow and develop in a bottom-up manner.

The next chapter will bring the discussion back to architecture by examining current approaches to 'sustainability' within the architectural discourse and their reliance on linear, mechanistic methods of development. It will then offer the ecological principles as a way to enhance current notions of sustainable architecture.

9. Introduction to Section Two

The aim of the discussion in the following section is to provide an overview and critique of current approaches to sustainable architecture, with a focus on three main topics:

(1) The relation to nature

(2) The relation to the user

(3) The relation to technology

The reason for choosing these three topics as the main focus of the discussion, and dismissing others, such as cultural or economic issues, is due to the limited nature of the research, coupled with the realisation that the relation to nature is a central issue in the environmental discourse, and it therefore seemed appropriate to use it as a main focus for investigation within this thesis. Acknowledging the relation to nature as a main topic for investigation brought forward the question: *who* or *what* relates to nature within the context of architecture? The answer to this question led to the second topic, which is *the user* of architecture, or rather; if the first topic is described as "the relation to nature" within the sustainable architectural discourse, then the second topic may be described as "the relation to the user" within the sustainable architectural discourse, or: what is the role of the user within sustainable architecture? The relation between the user and nature then led to the third topic, which can be defined as the interface which enables this relationship to exist within the context of the built environment. This interface may be architecture itself, or, more precisely, the design and technology that is employed as part of the architecture, and which enables (or disables) the user to relate to nature in a specific way. The third topic, therefore, is defined as "the relation to technology" within the sustainable architectural discourse, and technology is defined very loosely in this context to include the tools and methodologies employed as part of the architectural system. The discussion in the following chapter, then, will aim to explore how the relationship between people and nature is currently being addressed within the sustainable architectural discourse, and whether an understanding of ecological principles can inform it in some way. It will begin by investigating the different approaches within sustainable architecture in relation to nature, user, and technology. It will then proceed by proposing a new interpretation of the possible inter-relations among the three topics (nature, people, and technology) by using the ecological principles from the previous chapter as a filter for the concluding remarks.

The sustainable architectural discourse will be examined in the following section according to three main topics, as explained above, and these are:

(1) **Nature** – the first topic to be discussed is the relation to nature within the sustainable architectural discourse. It is assumed that nature is a significant issue (if not the most significant) to be considered within the sustainability discourse, and that the relation or attitude towards nature that a designer or an architect may hold will highly determine the outcome of a design solution. It is therefore essential to consider and examine the prevailing attitude(s) towards nature within the sustainable architectural discourse.

(2) **Users** – the second topic to be discussed is the relation to the user(s) within the sustainable architectural discourse. As ethical concerns towards nature and the environment come into focus within the discussion on sustainability, it seems that the relation to the user of architecture, as an individual as well as a society, comes into light as well. What is the role of the

user(s) within sustainable architecture and how does he/she participate in achieving overall sustainability goals?

(3) **Technology** – the third and final topic to be discussed is the relation to technology within the sustainable architectural discourse. Technology, in this context, is defined as the practical set of ideologies, methodologies and tools, derived from scientific discoveries, which are applied by architects in their designs. In order to be able to generate an ecological set of relations between people and nature, through architecture, it is essential to understand what is the role of technology in setting about such relations, so that it can be employed in a way that promotes rather than restricts ecological relations in the environment.

The three topics (nature, user, technology) will be explored separately, within each chapter, in the context of sustainable architecture discourse, and the existing stances in relation to each one of them will be exposed and discussed in turn. The conclusions from the three chapters will aim to explore how architecture might be able to further support interrelations among people and nature by drawing on the ecological principles from the previous chapter.

10. Relation to Nature

In the following chapter the discussion will aim to reveal several different attitudes to nature, which are currently evident in the sustainable design discourse. The discussion will proceed through an exploration of three main attitudes to nature within sustainable design:

1. Nature as the "unknown" - that which is feared and from which humanity still needs protection.
2. Nature as a limited source of materials and resources, which must be protected and conserved.
3. Nature as an unlimited source of inspiration.

10.1 Nature the Unknown

The need of humanity to protect itself from unknown and unpredicted natural forces is as old and fundamental as human existence. Unlike other animals in nature, human beings have always had the capacity to reflect upon their condition in the world and experience their separateness as well as their belonging to nature.

> Nature is that which humanity finds itself within, and to which in some sense it belongs, but also that from which it also seems excluded in the very moment in which it reflects upon either its otherness or its belongingness (Soper, 1995: 49).

Soper identifies that it is human *capacity for reflection* which excludes it from nature. The moment that human beings begin to reflect upon their situation in relation to nature is the moment when they begin to feel the need for protection because they no longer regard themselves as an integral part of nature. Once humanity began to foster its condition of separateness from nature, it forgot, with time, the other condition of its being – the condition of belonging to nature. The obsession with protection grew and developed from a *temporary* condition of separateness into a *permanent* one.

> Civilised man was nearly always able to become master of his environment temporarily. His chief troubles came from his delusions that his temporary mastership was permanent. He thought of himself as "master of the world", while failing to understand fully the laws of nature (Schumacher, 1973: 81).

Schumacher supposes that the major transition in humanity's relation to nature occurred when humanity began to regard itself as a permanent master of nature rather than a temporary one. This shift in relation changed the attitude of humans to nature from that of fear and respect into that of (apparent) control and dominion. This sovereignty of humans over nature, with time, led to a complete sense of separateness from nature; "Modern man does not experience himself as a part of nature but as an outside force destined to dominate and conquer it. He even talks of a battle with nature, forgetting that, if he won the battle, he would find himself on the losing side" (Schumacher, 1973: 3). Schumacher's remark echoes with current environmental problems, many of which are attributed to the irresponsible action of humans. Many environmental problems, such as pollution and global warming, are considered harmful not only to natural systems, but also to human life. In this sense, the human battle with nature (i.e. human irresponsible acts toward nature) set in motion a cycle of natural phenomena which reverberate to endanger human life. These arguments about the consequences of human actions on nature led to the development of an 'environmental ethic' – a philosophical discipline developed in the 1960s and 1970s, which studies the moral relationship of human beings to the environment, and the value of the environment and its nonhuman contents (Brennan, 2008). When environmental ethics first emerged as a new sub-discipline of philosophy, it posed a challenge to traditional anthropocentrism by questioning the assumed moral superiority of human beings to other species on earth. It investigated the possibility of rational arguments for assigning intrinsic value to the natural environment and its nonhuman contents.

Environmental ethics generally distinguished between two types of values – *instrumental value* and *intrinsic value*. The former is the value of things as means to further some other ends, whereas the latter is the value of things as ends in themselves regardless of whether they are also useful as means to other ends. It is commonly agreed that something's possession of intrinsic value generates a *prima facie* direct moral duty on the parts of moral agents to protect it or at least refrain from damaging it (Brennan, 2008). Those arguing that nature possesses intrinsic value can generally be divided into two main streams of thought. One, represented by Paul Taylor's argument can be called *biocentrism*, and the other, advocated initially by Calllicott, can be referred to as *holism*. Biocentrism argues that each individual living thing in nature – whether an animal, a plant, or a micro-organism – has a 'teleological centre of life' having a well-being of its own, which entitles them to moral respect. Holism, on the other hand, argues that the earth's biotic community per se is the sole locus of intrinsic value, whereas the value of its individual members is merely instrumental and dependent on their contribution to the integrity of the larger community of which they are part (Brennan, 2008).

The growing awareness to environmental issues in the late 1960s and 1970s, coupled with human landing on the moon in 1969, began to have a combined influence on some designers and architects.

In his paper *The Closed World of Ecological Architecture* Peder Anker describes how architects and planners in the 1970s began to adopt space technologies in order to formulate a new environmental ethic in architecture.

> In the 1970s, environmental ethics became an issue of trying to live like astronauts by adapting space technologies such as bio-lavatories, solar cells, recycling, and energy saving devices. Technology, terminology, and methodology developed for the ecological colonisation of space became tools for solving environmental problems on earth (Anker, 2005: 530).

The irony of the adaptation of space technologies to solve environmental problems on earth may seem completely plausible if we understand the panic that accompanied environmental issues when they were first introduced. The prevailing attitude was that humanity must learn how to live completely independent of nature, since an environmental catastrophe was pending and an urgent solution for humanity's continued survival was needed.

> It was an urgent need to design fully functioning self-contained environments, capable of sustaining human life over long periods instead of creating buildings which exploited the environment (Anker, 2005: 528).

Some examples which Anker mentions include John Todd and *New Alchemy*'s bioshelters, which sought to build "closed ecological systems on Earth and develop an ecological managerial system for land and buildings inspired by the ideal of imagined future space colonies" (Anker, 2005: 536). Anker mentions that the New Alchemists were motivated by a deep seated fear of not surviving the earth's coming ecological collapse, and with their bioshelters tried to emulate the concept of Noah's Ark (Anker, 2005: 536).

Alexander Pike and John Frazer from Cambridge University, followed by Brenda and Robert Vale's 'Autonomous house' aimed to develop autonomous structures that would not harm the environment. But probably the most extensive, ecologically-closed project was *Biosphere 2* in Arizona planned by the architect Paul Hawes and completed in 1991, which was a model for a fully enclosed planned ecosystem.

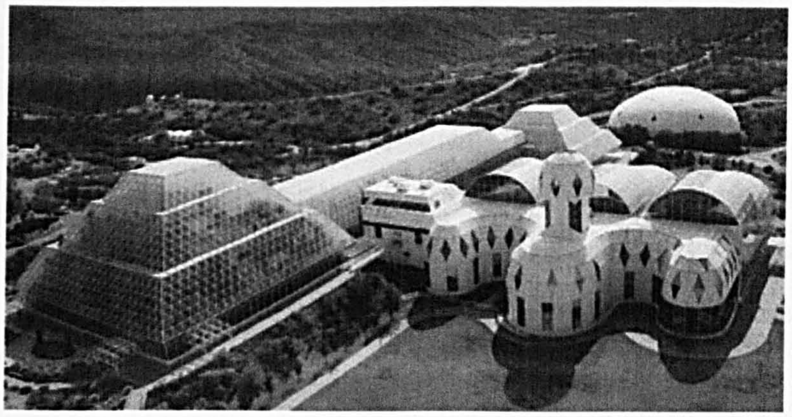


Image 5 - Biosphere 2 in Tuscon, Arizona
(http://www.nature.com/nature/journal/v447/n7146/images/447759a-i1.0.jpg)

These projects and others exemplify an ecological trend which aimed to create buildings and entire communities which were sealed off both environmentally and culturally from industrialised society (Anker, 2005: 542). This attitude represented a view which regarded nature and the environment to be unpredictable, and therefore required a planning approach which seeks ways to protect oneself and society in general from the environment, rather than fully integrate with it. From that particular point of view, it made sense to utilise technological systems and materials (borrowed from space technologies) as a source of solution; "It was an ethic which favoured a technological and scientific view of human beings at the expense of wider social and cultural values" (Anker, 2005: 545). The lesson that can be taken from Anker's analysis of the 1970s 'closed world of ecological architecture' to 21st century's sustainable architecture, is that an obsession with technological solutions and closed-off protective environments may not be the right way forward for environmental ethics in architecture. Architecture, rather, may be better off by attempting to find ways to re-integrate with wider natural and social systems and search for local solutions within those familiar systems instead of closing itself off in a bubble of technical terminology.

The fear of nature manifested in today's 21st century western culture may have changed its face but is not completely abolished. Murphy suggests that developed human powers have created a situation in which nature appears to be disappearing and is therefore feared less, but that in fact, nature cannot be abolished and it ultimately finds new ways to manifest its powers within our society.

> The elimination of *external* nature on Earth must not be mistaken for the abolition of *autonomous* nature. Nature retains its independent character even as humans struggle to control it and as expanding social constructions internalise dynamics of nature into society. As human constructions affect the self-regulating mechanisms of nature and invade virgin wilderness, emergent processes of nature invade society to operate alongside old ones. The other is still with us, but nature has become the other working its autonomous processes within society rather than outside society in pristine wilderness (Murphy, 2002: 316-7).

Murphy suggests that we have lost the capacity to protect ourselves from nature. Nature can no longer be viewed as external to human culture – it is now an integral part of our society in many complex and intricate ways which we can no longer completely control or predict.

It therefore may be the right time to shift the focus from trying to protect ourselves from an external or internal nature to learning to accept that nature is everywhere – it is part of who we are as biological beings and it is part of the way we act and respond as individuals and as a society to the world. A better attitude may be to begin to learn more about nature's behaviour and nature's own needs.

10.2 Natural Conservation

The first step toward an acceptance of nature may be the realisation and acceptance of the impact that human civilisation has on nature and a willingness to address some of its consequences. Human capacity to reflect upon its relation to nature may also entail some responsibility towards it, which other natural beings do not possess.

> Humanity viewed as a collective subject is thus both a 'spontaneous' or 'natural' product of its interaction with nature, but also an active agent who - unlike the spider or the bee - is responsible for the forms of that interaction and in principle capable of transforming them. Humanity is both the creature of nature and its creator (Soper, 1995: 47).

Human responsibility towards nature, which first came into public awareness during the 1960s, with publications such as Rachel Carson's *Silent Spring* in 1962, and Paul Ehrlich's *The Population Bomb* in 1968 (which warned about the growth of human population that threatened the viability of planetary life-support systems), have finally led to publicly accepted guidelines for action concerning sustainability, only in the beginning of the 1990s, with the first United Nations Conference on Environment and Development in Rio de Janeiro in 1992.

Similarly, in the field of architecture and design, it can be argued that although some pioneering attempts at ecological solutions already began in the 1960s and 1970s (as mentioned in the previous paragraph), public awareness to environmental issues within the design and architecture disciplines, became much more widely appreciated and accepted during the 1990s. The focus now seemed to be more on the creation of 'better integrated' designs, with reduced negative impacts on natural systems, rather than on completely autonomous and self-sufficient environments. The definitions varied from 'environmental' and 'sustainable' to 'green' and 'ecological';

> We define "ecological design" as "any form of design that minimizes environmentally destructive impacts by integrating itself with living processes." This integration implies that the design respects species diversity, minimizes resource depletion, preserves nutrient and water cycles, maintains habitat quality, and attends to all the other preconditions of human and ecosystem health (Van der Ryn & Cowan, 1996: 18).

'Respect for nature' is a common motto in sustainable design and can be interpreted in different ways by architects. The main agreement between the different interpretations of sustainable design can be regarded as the attempt to integrate the design as best as possible with local natural systems. This is practically achieved by extracting the least possible raw materials from nature and minimizing the environmental impact of the building in terms of its emissions, during construction as well as during the continuous life of the building. Since it is difficult to measure the extent to which a building is 'well-integrated' with local natural systems, sustainable architects tend to focus on the measurable criteria for sustainability. These are typically the amount of materials extracted from nature and the sum of negative emissions of the building on the natural environment. Ken Yeang describes the points of interaction between a building system and its environment as 'transfer points' – these are the points at which a building, as a closed entity, interacts with its external environment. The transfer points should be acknowledged and controlled by the architect. According to Yeang:

> From the ecologists' point of view, architecture as the consequence of design results in a built form that represent a net statement of its physical and potential demands and influences on the ecosystem and on the earth's resources. To determine these demands and influences, we must trace the uses of energy and materials in the designed systems in the form of the routes that they take from their environmental sources to the designed system's dependencies and to the end of their useful life (Yeang, 2006: 63).

Although Yeang claims to apply an open systems[7] view to his architectural approach: "an open general systems framework can be used to visualise 'sets of interactions' taking place between the designed system and its environment" (Yeang, 2006: 64), he ultimately promotes a view of architecture as a closed system. This is exemplified in his description of the building as a system which contains minimum 'points of interaction' with the environment, and these points should be controlled and monitored by the architect, in order to minimise undesired negative impacts of the building on the ecosystem. This description entails that building occupants cannot freely exchange energy and matter with the environment, through the building, as an open system would promote, but rather, the building functions more as a closed system which is a system "whose behaviour is entirely explainable from within, and which has no interaction with its environment" (Heylighen, 1998). It is true that an architectural system does exchange energy and matter with its environment, but as Yeang explains, the amount of this exchange should be monitored and limited. In this sense, it can be argued that sustainable design tends to promote 'more closed' and 'less open' systems in buildings. This is generally promoted by feeding back (for example, through recycling) and minimizing import of materials and

[7] Open systems are defined as "systems which have inputs and outputs, and which are capable of changing their behaviour in response to conditions outside their boundaries" (Heylighen, 1998).

export of waste, so that the input and output rules are easier to satisfy because there are less of both (Williamson et al., 2003: 84). Although from a practical point of view, this kind of approach is desirable in order to promote less wasteful buildings, it is problematic conceptually, because it promotes a persisting distinction between architecture and its environment.
Instead, a conceptualisation of architecture as an *open system*, which promotes rather than restricts exchange and interaction with its environment, has a better potential to encourage environmental awareness in users, in comparison with a closed system that restricts those exchanges in the first place.

Some designers and theorists acknowledge the fact that sustainability criteria are at times applied superficially to buildings and designs. Charlick & Nicholson are concerned that much sustainable architecture deals in symbolism: "the green roof or the solar array represent a 'green' sensibility, which may extend no further than this" (Charlick & Nicholson, 2001: 68). McDonough & Braungart point to the real complexity of sustainability issues and raise their concerns in regards to the ease in which concepts like 'energy-efficiency' or 'recycling' are now used as common labels by people who fail to understand their deeper meanings.

> Just because a material is recycled does not automatically make it ecologically benign, especially if it was not designed specifically for recycling. Blindly adopting superficial environmental approaches without fully understanding their effects can be no better - and perhaps even worse - than doing nothing (McDonough & Braungart, 2002: 59).

Williamson et al. agree that sustainability is difficult to apply and point to the fact that sustainability criteria can and should be applied differently according to context.

> Sustainable designing means taking responsibility to anticipate the wide consequences of a building proposal. Believing that all publicly endorsed codes of practice are sufficient to give the answers, to put things in order, is mistaken. No attempt to accommodate the real complexities of the world in neat regulations will lead to a sustainable architecture, and the complexity of each project needs to be considered in its context (Williamson et al., 2003: 126).

The real complexities that sustainability raises for architects and designers are wide and vary from project to project. It is therefore difficult to establish a definitive model for sustainable design. This complexity of the issue seems to encourage a tendency to search for 'short-cuts' or ways to make sustainability more comprehensible and easier to apply quickly in a demanding market.

In addition to the potential danger of applying certain aspects of sustainability in a superficial way, there is also a tendency to believe that if certain sustainable methods are applied comprehensively then all problems associated with environmental issue can be solved. One of these methods which are often applied is *eco-efficiency*;

> Eco-efficiency would transform human industry from a system that takes, makes, and wastes into one that integrates economic, environmental, and ethical concerns. Industries across the globe now consider eco-efficiency to be the choice strategy of change (McDonough & Braungart, 2002: 51).

The main problem with eco-efficiency, as McDonough & Braungart suggest, is that does not significantly alter human impact on natural systems.

> Reduction is a central tenet of eco-efficiency. But reduction in any of these [cutting toxic waste, emissions, product size] areas does not halt depletion and destruction – it only slows them down, allowing them to take place in smaller increments over a longer period of time (McDonough & Braungart, 2002: 54).

Eco-efficiency, although on the surface seems to be a positive solution for current destructive industries, can actually turn out to be more harmful for natural systems than a sudden collapse.

> An ecosystem might actually have more of a chance to become healthy and whole again after a quick collapse that leaves some niches intact than with a slow, deliberate, and efficient destruction of the whole (McDonough & Braungart, 2002: 63).

This kind of misconception in regards to environmental and ecological processes points to the necessity to better understand how ecological systems behave. Understanding only one natural process or concept and applying it in isolation within projects, without taking into account its wider environmental or social consequences, is highly problematic, and can, at times, cause more harm than good, as exemplified above.

Proponents of eco-efficiency within architecture, such as Ken Yeang, Norman Foster, Richard Rogers and other architects, generally tend to back-up advanced technological solutions for the reason that they can offer higher efficiency levels in systems within buildings. For example, Norman Foster's *30 St. Mary Axe* building in London employs an automatic high-tech window-system, which augment an air-conditioning system with natural ventilation, and is anticipated to save energy for up to 40% of the year (Great Buildings online Database, 2005).

The performance of advanced technological systems may be higher, in terms of energy efficiency, than low-tech or natural materials, but they do have other environmental costs. Their production takes more energy and produces more pollution than low-tech materials, and they usually end up as 'industrial waste' when their life is over. As Hagan points out, the process of trading off environmental costs against results is a minefield, mapped less by science than ideology. "If you are 'for' modern technology, then you will rationalize your choice of energy expensive materials and technologies. If you are 'against' modern technology, then you will argue in the opposite direction" (Hagan, 2001: 87).

One possibility to bridge the gap between proponents and opponents of advanced technological solutions may be by eliminating the concept of industrial waste. McDounough & Braungart suggest that "form should follow evolution" instead of function, meaning that products and systems should be designed in the first place on the understanding that waste does not exist. In their suggestion, every product can be fed back to one of two metabolisms - the biological cycle or the technical cycle.

> There are two discrete metabolisms on the planet. The first is the biological metabolism, or the biosphere - the cycles of nature. The second is the technical metabolism, or the technosphere - the cycles of industry, including the harvesting of technical materials from natural places. With the right design, all of the products and materials manufactured by industry will safely feed these two metabolisms, providing nourishment for something new (McDonough & Braungart, 2002: 104).

The idea of two metabolisms which can embrace all future-designed products is an idea which begins to suggest an encompassing solution for a sustainable design. It reaches deeper than eco-efficiency by providing a creative solution for nature and industry to exist side by side without compromising one another. It is an idea which derives inspiration from natural cycles and applies them to human industries without neglecting natural conservation.

10.3 Nature as Inspiration

The tendency to look to nature for inspiration and ideas is not new but it seems to be reappearing today on a new level. Every human tradition at any point in history had its own definition and unique relation to nature, depending on its history, heritage, and dependence on local natural resources (Bech-Danielsen, 2003). Some go as far as claiming that there is no 'nature' external to the cultural discourse that constructs its 'truth' (Soper, 1995: 120). The interdependence between nature and human cultures exists both on a practical and a conceptual level, and this interdependence is constantly redefined as a result of changes in human conception of nature and as a result of changes in human dependence on nature in each particular culture. Bech-Danielsen elaborates on this interdependence;

> Every culture, in point of fact, contains its own particular conception of nature, and different cultures cultivate different forms of nature, depending on their own conception of nature. If a culture loses sight of its natural foundation and perishes as a result, a new culture can evolve only when people discover a new form of nature to cultivate – when a new view of nature has been established (Bech-Danielsen, 2003: 336).

According to Bech-Danielsen, the development of culture is based upon this culture's way of cultivating nature, and in that sense, nature provides the background, the basis, from which a culture can develop, and remains a guiding or limiting factor in the growth of that culture.

The relationship between nature and culture is also reflected in the relationship between the 'natural' and the man-made. Is there a difference between the two? Are products made by man considered to be 'natural'? This argument is important because it introduces the significance of man-made products in relation to natural products, and the role of architecture (man-made) in relation to nature and its 'right' to exist.

> It is worth distinguishing in the many accounts of architecture's relationship to nature between those that propose that architecture is *like* nature, in that it follows the same laws or imitates it, and those that say that architecture *is* nature – that in so far as man and woman are objects of nature, architecture's providing them with shelter or symbolic expression makes it a natural product, in the same way that speech is. Architecture in this sense is seen as a condition of mankind's being in the world. The problem faced by those twentieth-century theorists of architecture who rejected both propositions was to establish, if architecture neither is nature nor is like nature, what it then is (Forty, 2000: 220).

Forty introduces a fundamental argument about the 'right' of architecture to exist in relation to nature. If architecture is indeed a condition of human existence in the world, then it could be considered as natural as a spider's web. But what happens when architecture begins to harm natural systems in an irreversible way, the way it seems to be harming today? Can it still be justified as 'natural' under such conditions? There obviously seems to be a big difference between human architecture's impact on the earth and the influence of other 'natural' constructions. From this point of view, it seems quite clear that human architecture develops according to tunes which are quite drastically different than those of nature. The reason for that may be related to human capacity for reflection and rational thinking which takes us beyond the 'natural' ways of behaviour into a realm of mechanic/linear/technical ways of action which do not necessarily respond to those of nature. It may therefore be the case that it is not a prerequisite that *any* type of human creation should be considered either 'natural' or 'unnatural,' but rather, the focus should be transferred to the *way* in which a thing was created - whether by 'natural' means or by mechanical/linear means. It can be part of nature by utilising organic

or ecological ways of behaviour and action, or it can choose to be opposed to nature, by continuing to utilise a linear, mechanical way. During the 20^{th} century, rational/linear ways of thinking have slowly come to dominate many areas of human life outside the sciences and economics. It was Weber who spoke of the "rationalisation" of society. By rationalisation Weber meant systematisation and organisation by means of rational principles (Dusek, 2006: 53-4). One of the most important elements of postmodern thinking has been the rejection of linear ways of thought as the only legitimate procedures of knowledge (Ben-Dov, 2000: 4). Mechanical and linear explanations, which proceed in a fixed one-dimensional chain from the first cause to the last effect, are no more accepted as satisfactory in many applications. Instead, growing attention is centred on the image of a web with a huge multitude of nodes and interconnections, so that there is no single predetermined and necessary trajectory (Ben-Dov, 2000: 4).
Deleuze & Guattari developed the concept of the rhizome (based on a term borrowed from botany) which describes an open structure with many links or connections to the outside, and which can continuously grow and develop in those different directions (Deleuze & Guattari, 1988). Both the rhizome and the web image are attractive concepts because they offer a possibility to develop an intellectual and operational structure which is based on order found in natural systems, which is complex yet flexible. The appeal of the web-like or network structure of complex living systems is, according to Coyne, also related to the interplay between simplicity and complexity that they offer;

> Part of the appeal of networks is their participation in this play between simplicity and complexity. The simple involves planarity, the complex is non-planar. Parts of networks can be simple as visual entities, but the combination of these simple components produces something complex. The behaviour of the part is

> comprehensible, calculable and can be drawn on a sheet of paper. The whole may be incomprehensible, involve very complex calculations and be impossible to represent... Arguably, the network derives much of its authority from this capacity to maintain simplicity in the detail, while suggesting complexity in the whole (Coyne, 2005: 9).

As the study of natural systems develops to include studies of *interactions* between systems rather than focus on the study of individual natural elements, there is a growing understanding of the complex ways in which natural systems are formed.

Deriving inspiration from nature is not a new idea in itself but the way in which it is done today is new and innovative. Some attribute this new knowledge of natural systems to our ability to observe them with technological tools. Different computerised simulations allow us to be able to observe very complex behaviour of natural systems, which have not been previously possible, and to understand them in new ways. This new space of understanding natural systems, which is opened by technological developments, is claimed by some to have broken philosophical barriers between human and natural systems, and to provide new integrative strategies between technology and nature (Charlick & Nicholson, 2001: 68). Whether or not these claims are true remains to be proven, but in the meantime, it seems that while technologies enable new ways of understanding natural systems, they do so by maintaining an objective, detached point of view over them. This is considered by some to be the fundamental problem of the scientific legacy that must be overcome if we are to solve any of our environmental problems over the long run (Wilber, 1996).

The detached, observant point of view on natural systems is also manifested in the architectural field. New ideas about the complexity of the natural world, from chaos theory to fractal growth, have influenced architects and designers in various ways, although the results, in many cases, suggest mainly a formalistic expression of such ideas. Charles Jencks (1995) in his book 'The architecture of the jumping universe' and other articles, describes six different categories for compartmentalizing contemporary architecture, which, according to his view, manifest latest scientific discoveries. These categories are:

1. *Organi-Tech* – architects continuing an obsession with technology and structural expression while at the same time taking into account environmental aspects. (Ken Yeang, Renzo Piano, Richard Rogers, Nicholas Grimshaw)
2. *Fractals* – expressing self-similar, evolving forms, rather than self-same elements. (ARM, Morphosis, LAB, Bates smart)
3. *Computer blobs* - 'blob grammars' and abstruse theories based on computer analogies - cyberspace, hybrid space, digital hyper-surface. (Greg Lynn)
4. *Enigmatic signifier* – searching for inventive and emergent metaphors that will amaze and delight but are not specific to any ideology. (Frank Gehry - The Bilbao museum, Rem Koolhas, Coop Himmelblau)
5. *Datascape* - constructing datascapes based on different assumptions and then allowing the computer to model various results around each one. These are then turned into designs which create new forms of bottom-up organisation not possible to realize before the advent of fast computation. (MVRDV)
6. *Landforms* – The basic metaphor of the earth as a constantly shifting ground rather than the terra firma we assume. Matter comes alive in this architecture at a gigantic scale. (Peter Eisenman, FOA's Yokohama Port Terminal)

Jencks then maintains that architecture is the first field in human culture to consciously express the new scientific discoveries, or what he calls 'The new paradigm.' This assertion is misleading since there are several manifestations in various fields relating to ecology, systems and complexity theories[8], and Jencks chooses to ignore them.

Salingaros (2004), a mathematician and architectural theorist, disagrees with Jencks' assumptions about architectural representations of the new sciences. Salingaros claims that the architectural manifestations that Jencks sees as representing new scientific ideas, are only sculptural representations of certain abstract ideas but do not actually represent the continuous, complex processes that are manifested in living systems. "It turns out that there is a basic confusion in contemporary architectural discourse between processes, and final appearances. Scientists study how complex forms arise from processes that are guided by fractal growth, emergence, adaptation, and self-organisation. All of these act for a reason. Jencks and the deconstructivist architects, on the other hand, see only the end result of such processes and impose those images onto buildings" (Salingaros, 2004: 45).

The problem with adopting a detached view on nature is therefore clearly manifested in architecture, where new ideas related to complex systems and ecology are mostly expressed in formalistic and stylistic solutions to the building as "an object," rather than adopting an approach which considers the built environment as an ongoing process of interactions between various systems.

One way to break this detached point of view on natural systems is suggested by Gadow, in her research on medical practices. Gadow introduces the concept of *inherence* as an essential stage for reaching deep ecological understanding. It is the difference between

[8] The study of living systems - how they interact, function and develop, have influenced many fields outside the sciences. Researchers in: Philosophy and Ethics *(Naess: 1973),* Education *(Orr: 1992, O'Sullivan: 1999),* Economics *(Arthur: 1999, Becker: 2006),* Sociology *(Schumacher, 1973, Bookchin: 1987),* Engineering *(Sendzimir: 2002),* Psychology *(Bateson: 1979),* Neurophysiology *(Maturana and Varela: 1973)* and others, are finding ways to apply the new scientific findings to their fields in various ways.

understanding the interrelatedness of living, complex systems through observation, and actually experiencing it and becoming part of this living web.

> Inherence - revising theoretical into existential engagement revises nature into a lived rather than objective whole. Nature remains an irreducible web of relations, but experienced from within instead of surveyed from without. It is a whole in which humans inhere.... Inherence means that relations are reciprocal... While human existence always organizes the world around itself, it is never exempt from its world... The practical meaning of inherence is the experiencing of nature locally rather than colonially... The difference between local and colonial views of nature is the difference between a sense of place and concepts of space.... Spaces are abstract; place is particular (Gadow, 1992: 601).

It may be argued that the study of ecology, unlike systems theories and complexity sciences, attributes more importance to the type of system that is being observed and its relation to the wider context of which it is part. In that sense, ecology may be regarded as a less abstract and detached observation of complex systems than general systems theories and complexity sciences. As Manzini clarifies the meaning of ecology;

> "Ecology" here doesn't mean green, and all that that word stands for. It means a particular structure of the system, the meta-system in which you have many different systems that co-operate and compete. Ecology is the very complicated relationship within a system that is based on co-operation and competition. An ecological approach is when we read the space of flow and the space of networks [as a whole] (Manzini, 2002: 2).

The ability to understand nature's behaviour as a complex system is one step in a transition from an object-oriented view of nature to a system-oriented view.

Deriving inspiration from nature on a systemic basis means being able to observe complex systems in nature and understand how they function, and then utilise the same principles of behaviour in different social and cultural structures. But the transition from observing nature as a collection of objects to observing nature as a collection of systems still maintains a detached, observant point of view. Therefore, a truly ecological architecture will aim not only to conserve natural systems, as sustainable architecture aims to do, neither to derive inspiration from nature on a systemic basis, as some technical, 'smart' systems do, but to enable new ecological relationships to emerge between people and nature, through the technology employed, which are based on an understanding of ecology and of human inherence within ecological systems.

10.4 Conclusions

The attitude to nature within sustainable design discourse ranges from fear of the unpredictable aspects of nature, which results in a need to protect the built environment and its users from such possible catastrophes; to an affirmation of human responsibility towards nature, which results in various actions that aim to minimize buildings' impact on the environment; to a tendency to derive inspiration from nature on various levels, which results in attempts to emulate natural processes within building design.

Each one of the above approaches to nature can be interpreted in a way which will preserve the current separation between architecture and nature. Therefore, a viable conclusion from the above discussion may be presented as the acknowledgement of the need to integrate between apparently separate natural and architectural processes, not only through their operational domain, but also through their experiential domain. In other words, acknowledging our interdependencies with natural processes, and then expressing those interdependencies through the design, by aiming to integrate not only the building itself, as an object, but also the experience of the user with natural processes, and by that promoting human *inherence* with nature, through design.

The discussion in the next chapter will proceed to examine how people ('the users') are perceived in the sustainable architecture discourse, and whether or not their inherence with natural processes is explicitly promoted in sustainable design.

11. Relation to the User

In the following chapter the discussion will aim to reveal several different attitudes to the user of architecture that are manifested in the current sustainable design discourse. The discussion will proceed through an exploration of three main prevalent attitudes to the user in sustainable design:

1. The user as an *obstacle* for achieving sustainability in design.
2. The user as an *integral* part of the sustainable design system.
3. The user as a *participant* in the design process for sustainability.

11.1 The user as an obstacle

Achieving sustainability in buildings may be considered by some designers a task possible independently of people's behaviour. It is considered, in that sense, to be a scientific problem capable of being solved by technical solutions, which are frequently manifested as 'add-on' environmental products or systems to buildings. Examples range from high-tech central control systems and efficient photovoltaics to low-tech water recycling systems, compost toilets, wind turbines, etc. The building, in this case, is viewed as an object which can be modified to suit sustainability criteria, and the wish to be able to evaluate and predict a building's environmental performance has led, at times, to a tendency which aims to replace, at least partially, unpredictable people's behaviour with tested, computerised control systems; "Watching users neglecting to turn off lights when there are already high levels of daylight in a room encourages a greater use of computer control. Machines can be instructed in a way people can not..." (Hagan, 2001: 114). Hagan refers to a tendency within environmental design according to which, users' unsustainable behaviour is aimed at being replaced by technical systems, that can automatically adjust light and heat levels to suit required conditions and by that significantly reduce over-energy consumption. Although such technical control systems can be highly efficient and desirable in certain circumstances (especially in public buildings), they also carry some drawbacks.

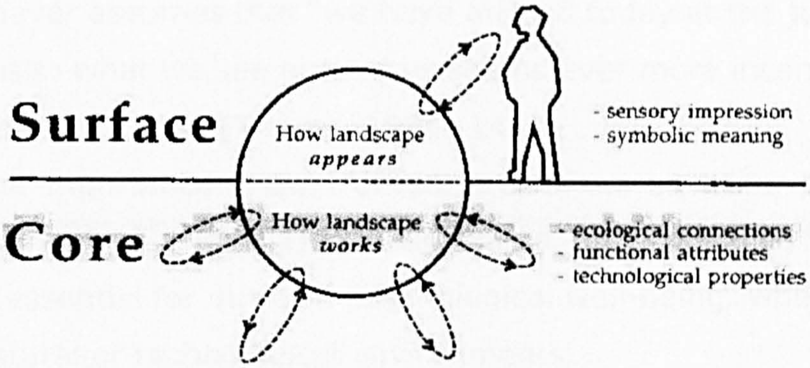
One of the main problems with such computerised control systems is that while they can be highly efficient in predictable environments, they usually become a hazard in unpredictable ones. Once an environment deviates from the 'norm', due to severe weather conditions, unpredictable situations or other accidents, computerised control systems can also become unpredictable, and may even stop functioning altogether (Gage, 1998: 81-4). This fact also leads to a tendency to try and maintain unified environments, which may induce unhealthy effects or simply promote one-dimensional, artificially steady conditions within a space. At times referred to as "organisms," computerised control systems or 'smart' systems are far from being able to adapt to unforeseen conditions, as an organism does.

Another argument against the proliferate usage of control systems in buildings is that they do not require people's involvement and therefore encourage environmental negligence in the long run rather than personal responsibility (Van der Ryn & Cowan, 1996). Environmental control systems in buildings ultimately increase our dependency on external technical systems for achieving sustainability instead of promoting self-sufficient capacity for environmental behaviour. Manzini assumes that one of the main problems with relying on technical, "relief from effort" systems, is that they lead, in the long run, to ignorance with regard to the way things function and how to look after them (Manzini, 2004: 4). Therefore, the use of computerised control systems in buildings may increase environmental sustainability of individual objects (buildings) but it decreases the capacity for people's individual environmental responsibility which ultimately influences the sustainability level of a society as a whole.

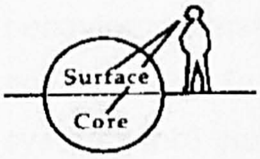
An additional point against the use of complicated technical environmental systems is that their functioning and maintenance remains barred to most people. This results in a loss of interest in how things really work and a mere satisfaction with surface appearances (Hamilton, 1973: 319). It may also lead to a feeling of helplessness in relation to the supporting environment and a need to rely on experts, instead of being individually empowered and in control of one's surrounding. People may feel that they cannot understand how systems in their environments work; how their ecological and technical infrastructures function.

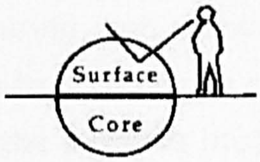
This, in fact, may have far reaching psychological consequences. Stephen and Rachel Kaplan proposed a theory of human preference for landscapes which allow a high degree of ability to become involved with and make sense of the environment. According to them, "natural" environments most closely resemble the primordial conditions in which the human mind evolved, and therefore, offer us an ability to satisfy both our need to comprehend existing conditions as well as our need to explore new territories (quoted in: Thayer, 1994: 12-14). This implies that environments which are incomprehensible may induce in us a sense of fear or exaggeration of the unknown (Thayer, 1994: 311). Surrounding ourselves with technological environments which do not reveal to us how they function may lead to unconscious feelings of stress and alienation in people with relation to their surrounding.

Thayer stresses the importance of designing 'landscapes' or environments which are tangible and comprehensible. The following illustration depicts different possible design solutions which can be extracted from 'surface and core' properties of landscapes.



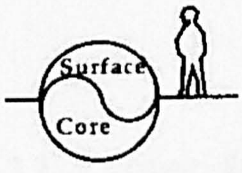
"Surface" and "core" properties of landscapes (Thayer, 1994: 141)

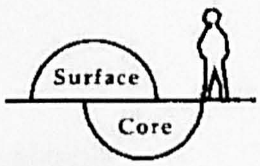




Transparent
"what you see is what you get"

Opaque
"you can't tell what you get"





Congruent
"what you see is compatible with what you get"

Incongruent
"what you see is incompatible with what you get"

Transparency vs. Opaqueness; Congruity vs. Incongruity in the landscape: the relationship between surface and core, or between "what you see" and "what you get." (Thayer, 1994: 141).

Thayer assumes that "we have arrived today at the juncture of great crisis: what we *see* around us seems ever more incompatible with what we *know*" (Thayer, 1994: 141).

The importance of the transparency of our environments is often overlooked, and as Thayer illustrates, understanding their 'essence' is essential for our own psychological well-being, whether they are natural or technological environments.

The tendency to replace users' activity and involvement in buildings with control systems in order to achieve constant, predictable environmental performance in buildings may be effective in some cases, for short-term sustainability, but it generates serious, long-term negative consequences in terms of people's environmental behaviour, sense of belonging, caring, and responsibility for the environment. In order to be able to incorporate complex technical systems into our environments, the systems must be made simple, accessible and comprehensible, and never aim to replace people but rather to compliment them and make the world more accessible for them to interact with.

11.2 User-Integrated designs

A different approach to the user in sustainable architecture is one which focuses on the user's health and well-being as an integral determining factor of the design. According to this approach, the user and his/her well-being is just as important a factor to consider as nature when designing for sustainability. The harmful relation of buildings to nature, which intrigued the need for sustainable architecture, is also characterised, at times, by negligence towards users.

> The success of the reductionistic and atomistic approach in science provided a sanction for self-referential approaches that seek to make architecture itself the focus of architecture. As this self-referential characteristic made architects neglect environmental factors including users and focus on a specific aspect of architecture, it became hard to deal with comprehensive human environments. It failed to produce user-responsive designs (Hahn, 1995: 7).

People's requirements for healthy and enhancing environments should be taken under consideration together with other natural beings' requirements for supportive environments. Since human beings are biological beings, their basic natural environmental requirements are not so far removed from those of other biological living beings. Qualities such as fresh air, clean water, natural light, and non-toxic materials are just as essential for humans as they are for other living creatures.

It is acknowledged today that one of the fundamental needs of human beings is the need to relate to nature (Ulrich, 1993), and this makes user-integrated designs and sustainable designs very compatible.

> *The biophilia hypothesis* boldly asserts the existence of a biologically based, inherent human need to affiliate with life and lifelike processes. This proposition suggests that human identity and personal fulfilment somehow depend on our relationship to nature. The human need for nature is linked not just to the material exploitation of the environment but also to the influence of the natural world on our emotional, cognitive, aesthetic, and even spiritual development. Even the tendency to avoid, reject, and, at times, destroy elements of the natural world can be viewed as an extension of an innate need to relate deeply and intimately with the vast spectrum of life about us (Kellert, 1993: 42).

User-integrated sustainable designs seek to focus on creating 'healthy buildings' (Pearson, 1995; Day, 2000) and can be traced back to the *Baubiologie* architectural movement in Germany in the

1950s. The aim of Baubiologie was to "create buildings in harmony with the environment, which address the biological, physical and spiritual need of their inhabitants. The building envelope, also considered the third skin (the second being clothes), should breathe, insulate and protect, while ensuring a healthy indoor climate" (Sassi, 2006: 96).

Designing 'healthy buildings' entails that designers take into consideration a variety of factors related to users' health, safety and well-being, which may not be normally addressed[9]. For instance, the influence of controlled air temperature (through heating or cooling) on users is rarely addressed but it influences the users in very subtle ways.

> Unchanging temperature, humidity and air-change rate is mechanically even. It does not stimulate our senses – which need constant subtle variations in stimulus to stay alert. We commonly refer to such air as 'dead'. Natural air, by contrast, changes from season to season, hour to hour, even minute to minute. It carries scents of season, weather, time of day and ongoing activities. In connects us, in other words, to life (Day, 2000: 137).

Day brings into light an over-looked factor which highly influences people's experience of the environment on a daily basis, almost in every building in the modern world. It reinforces the idea that increased comfort levels are not necessarily positive for the long-run development of human beings. It is indeed possible to have too much comfort, for the body may then lose its power of quick adaptation, which is an essential requirement for normal health (Williamson et al., 2003: 110). User-integrated designs aim to ask such questions, to understand what are the effects of some design solutions on the actual health and well-being of humans, in the short term as well as the long term.

[9] Sassi lists some of these factors to be considered (Supplement 2).

Studying the impacts of the environment on people's health introduces a number of difficulties, since people's reactions vary according to circumstances and individual preferences. Also, there are problems associated with testing individual characteristics of an environment in isolation, which consequently requires the collection of very large amount of data to create reliable statistics (Sassi, 2006: 98). Despite the difficulties, there is an increasing body of research into environmental health which can inform building design (Sassi, 2006: 98).

User-integrated designs also acknowledge the fact that environmental performance in buildings cannot be tested in isolation from their use. People are an integral part of buildings and environmental behaviour can only be achieved if the interrelations between people's behaviour and buildings' performance are considered, as Williamson et al point out;

> It is a well-documented fact that the thermal behaviour of people is contingent on the context. This means that it can never be assumed that people in a low rating house will behave the same if placed in a high rating house. Because the differences in behaviour will most likely effect energy consumption, there is no logical way that the *potential* to reduce energy consumption makes sense and can be tested (Williamson et al., 2003: 123-4).

The above quotation illustrates that environmental performance in buildings can be measured objectively only to an extent, and that users' involvement and engagement with the space may also have a large impact on the overall environmental performance. People's involvement with the building may influence not only the building's environmental performance, but also the well-being of the occupants themselves. It has been proven that where building occupants have the ability to change their environment, for example, by opening windows, they are more tolerant of variable temperatures than occupants without this ability (Baker & Standeven, 1995). The human desire for control extends to many aspects of life, and a perceived lack of control can be frustrating and stressful, and may affect an individual's sense of self-worth (Sassi, 2006: 99).

User-integrated designs offer a more encompassing and inclusive approach to sustainable architecture. Rather than viewing the user as an obtrusive element to the building, which cannot be controlled in the same way that the rest of the buildings' systems may be, it is an approach which begins to take into account the user's needs and integrate them into the design considerations. This approach to sustainability begins to 'open' the building system to outside forces which interact with it, so that the building is no longer considered as a 'closed' and detached object, but begins to be viewed as a more inclusive system, that looks at the wider processes with which it interacts.

The next section will take this approach further to investigate how user participation in the design process may contribute to sustainability goals.

11.3 User-Participation in design

Unlike user-integrated designs, the participative approach does not aim to design with the user in mind but rather to design *with* the user. It is an approach which acknowledges the need to involve the user in the design process.

The benefits may include an end result of a 'fuller' architecture – one which is based not only on the assumptions of the architect but on the true needs and aspirations of the users, and a better 'sense of belonging' from the point of view of the users - because rather than being passive recipients of the building they have been involved in the design process from its very beginning. Blundell-Jones, Petrescu and Till, in the introduction to the book 'Architecture and participation,' describe a gap that has been opened between the world "as built" and the world as "needed and desired;"

> Architects, needing clients with power and money, are usually on the side of those in power and willing to embrace and express in built terms the ideology and economics of the clients, to the exclusion of the desires of the potential users. There is thus a removal of the general public from the process of architectural production, which in turns leads to a sense of alienation of the users from their environments (Blundell-Jones et al., 2005).

According to their view, the participative approach is not merely a means to engage users more fully in the design and building of spaces, but also as a means to criticise and redirect architectural culture (Blundell-Jones et al., 2006: xv).
In relation to achieving sustainability in architecture, the participative approach can encourage a variety of different responses and interpretations to local environmental and cultural conditions. By engaging a wider variety of people in the planning process, the resulting building design may prove to be more suitable to the local environment. This more 'specific' architecture has a better chance of generating a place which is appreciated and cared for by the people who planned it and live in it. It also reflects, as a totality, a type of architecture that promotes cultural diversity, which is an inherent part of the concept of sustainability.

> Cultural diversity is humankind's contribution to maintaining the delicate balance in the variety of contextual circumstances throughout the globe. Maintaining this cultural diversity must be seen as an integral component of a sustainable architecture, because history would seem to show that variety among

> human societies is the source of adaptation and of innovation (Williamson et al., 2003: 89).

The notion of accommodating cultural diversity in architecture is also important in counteracting criticism on technologically-based sustainable architecture, which is considered to be uniform and failing to correspond to local places and cultures (Guy & Farmer, 2000: 80). The participative approach offers a way to address uniformity in architecture through a process which denies sole control over projects. As Habraken explains, rather than blaming technological tools for architectural uniformity, we should be putting the blame on centralised decision making processes (Habraken, 2000: 272). Participation can offer a valid opportunity for a variety of different ideas, responsibilities and decision makers to come together in an architectural project.

Another important benefit for sustainability through user-participation projects is that environmental awareness can be generated within the participants during the design process rather than being imposed on them as an idea by the designer. Through the process of design and relation to a specific site participants may have the benefit of learning about environmental issues and environmental behaviour during the process of searching for suitable design solutions (Thackara, 2005: 94).

But probably, the most interesting notion about participation in design is the idea of generating a bottom-up design process instead of a top-down imposition of form. The main advantage of bottom-up processes in comparison to top-down ones is that new order can emerge and new conditions can arise, which are usually eliminated in top-down processes because they do not correlate with the 'imposed' order. This new possibility for allowing different ideas and different opinions to be heard and influence the design process is one which is compatible with the ecological principles, through the idea of *emergence*.

An example to a bottom-up, participative architectural process is the design of the Gelsenkirchen school in Germany, which was led by the architect Peter Hubner. The main building complex of the school, including the layout and the common buildings, such as; sports hall, cafeteria, theatre, etc. were planned in close consultation with the teachers, and the separate classroom buildings were gradually added year by year. Their design and construction involved teachers and pupils directly. The process involved two pairs of project days when Hubner and his assistants visited the school to work with the pupils and their teachers. After the first session, the architects returned to their office to work up proposals based on the children's ideas. Six weeks later they returned for another two-day intensive session. After discussion and adjustment of the design, the children built precise models based on the architects' drawings. Much of the fitting-out and finishing was done by teachers, pupils and their parents (Blundell-Jones, 2005: 175-177).

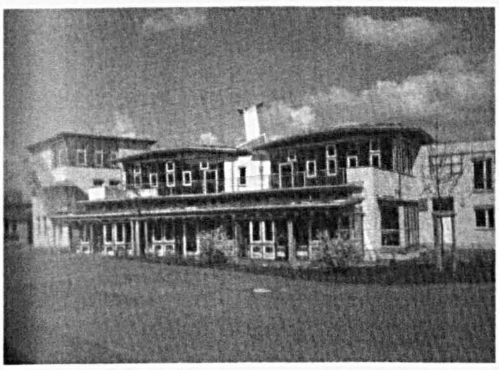


Image 6 - Gelsenkirchen school from the front.

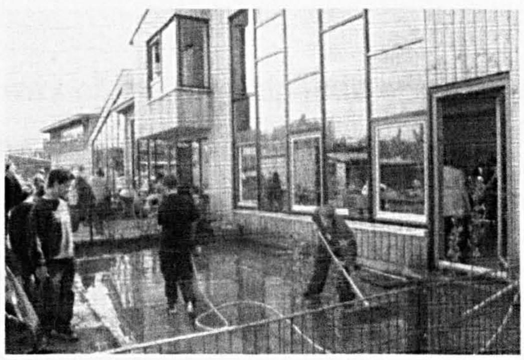


Image 7 - Pupils cleaning outside their Classroom.

The school had an ecological message of 'learning by doing' which was also applied in the landscape design. Landscape architect Christopher Harms developed a concept involving the children and their teachers which was even more open-ended than the classroom design. It became part of their education to make gardens of vegetables, herbs or flowers, to develop small fruit orchards, to collect water from the roofs, to keep small animals, to encourage butterflies and bees. "Children need to understand the landscape as a product of human endeavour, of our interaction and dialogue with nature. In seeing the results of their efforts to manipulate and control it, they discover their power to influence the world." (Blundell-Jones, 2005: 180)

The nature of such bottom-up processes is that they do not have to end. The newly created situation generates another one which then generates another one, and the process can continue to evolve endlessly. It is an open process which 'feeds' on outside influences and creatively integrates them inside as the process evolves and becomes richer.

> Participation should be understood as a progressive and evolving process that constructs itself inferentially, by both integrating and adjusting its aims according to the newly created situations. Participation is performative, it is 'to collage one's collage onto another collage', it cannot work through preconceived models (Petrescu, 2005: 53).

One of the main obstacles in the way of the participative approach in architecture is that it is alien to the current prolific methods of design, which proceed mainly in a 'top-down' manner - of a design which is conceived in the architect's head and is then 'imposed' on the given site and the users of the building. This reality of the status quo, which is supported and encouraged by property developers and investors, makes it difficult for alternative design models to be tested and encouraged financially. Still, there seems to be a tendency, in some countries, to move towards a more participative and inclusive design approach. This has recently been evident in new governmental policies, in Europe and the USA, to make participation a necessary part of public work (Blundell-Jones et al., 2005: xiii).

The participative approach, which aims to include users in the design as well as building processes, has the potential to open the architectural processes to become more inclusive and ecological for the long run.

11.4 Conclusions

Contradictions within sustainable design discourse are also evident in the different attitudes to the user of architecture.
Some sustainable design approaches, mainly those which also support high-tech solutions, tend to regard the user, at times, as an obstacle for achieving sustainability since he/she represents an unpredictable factor in the building's performance. Such an approach tends to result in 'sustainable' designs which do not require user participation in order to be able to achieve the maximum desirable environmental performance.
On the other hand, approaches such as user-integrated designs or user-participation tend to view the user as a central component which, in many ways, determines the direction of the design process.
While user integrated designs tend to focus on the well-being of the user, by creating healthy environments, and aiming to incorporate such requirements for well-being into the design considerations, user-participative approaches tend to involve the specific user of the building in question (as an individual or a group of individuals) as participants in the design process itself, thereby aiming at generating completely unique buildings which reflect individual requirements and tastes of people and local communities.
These three different co-existing approaches to the user within sustainable design discourse, point to a general confusion and lack

of agreement within the discipline on the specific role of the user and its contribution/or lack of contribution to achieving sustainability in architecture.
Following the conclusions from the previous chapter on nature, it becomes clear that in order to be able to promote human inherence in natural processes, it is essential to include the user in the design considerations, whether through user-integrated design approaches or through user-participation in the design process itself. It therefore becomes apparent that designs which exclude the user promote a relationship of detachment between people and nature and this is not desirable for an ecological approach.

The discussion in the following chapter may shed light on the role of technology, as the interface between people and nature, in promoting user-inclusive designs. How does technology influence our ideologies, methodologies and tools? And how does it relate to sustainable architecture?

12. Relation to Technology

In the following chapter the discussion will focus on the role of technology in the sustainable architectural discourse. Technology, in this context, is defined as applied scientific discoveries, which are apparent in three main differentiated domains:

1. Technology as applied scientific ideologies
2. Technology as applied scientific methodologies
3. Technology as applied scientific tools

12.1 Technology as Ideology

Technology, as an applied scientific ideology may refer to a stage where technology becomes a major cultural and economic force which, in many ways, determines the direction a society may take. Unlike the view where technological development is only a fragment of total development, as it partakes in an interaction with a host of other social and cultural forces (Naess, 1989: 95), those who see technology as an ideology believe it to be a dominant guiding force in the development of 20th century Western culture.

The English philosopher Francis Bacon, regarded to be one of the main leaders of the scientific revolution, believed that technological power coupled with knowledge of nature can regain humans the clarity of mind and purity of action that preceded their expulsion from the Garden of Eden (Dusek, 2006: 41). This type of belief system, guiding the main scientific revolutionaries of the 16th and 17th centuries, regarded technology to be much more than a set of tools. For Bacon and his followers, technology was a basis for an ideology of human progress and power over nature, achieved through scientific observations and experiments. Technology was regarded both as a means to achieve this power and as a symbol of human ability to control and direct its own future. The increasing ability of humanity to understand nature by scientific observation was therefore regarded as a positive manifestation of human power and was slowly applied to other fields of society and culture.

The French philosopher Jacque Ellul criticized the application of technique to all aspects of life and society in his definition of the "technical phenomena" (Dusek, 2006: 54). Ellul described technology as a set of rules which dictate a certain way of behaviour upon society. The problem with the pursuit of technology as an ideology and its wide influence on many areas of culture is that other alternative and traditional ways of thought and action are often ignored. Qualitative and intuitive ways of behaviour are dismissed, under the dominating technological reasoning, as "irrational" or "illogical", and viewed as negative and intrusive to the linear development of human reason.

A different view acknowledges technology as an ideological force which can compliment rather than completely replace traditional and intuitive ways of action. Jose Ortega, a Spanish philosopher, regarded technology as a *desire* rather than a *necessity*. Technology is not a matter of the "being" of humans but rather of their "well-being" (Verbeek, 2005: 37). Seen from Ortega's perspective, technological ideology can be conceived as dangerous if it "invades" human culture to such an extent that it becomes essential. But as long as technology remains relevant only on certain levels of application, then its contribution to society can be manifested positively.

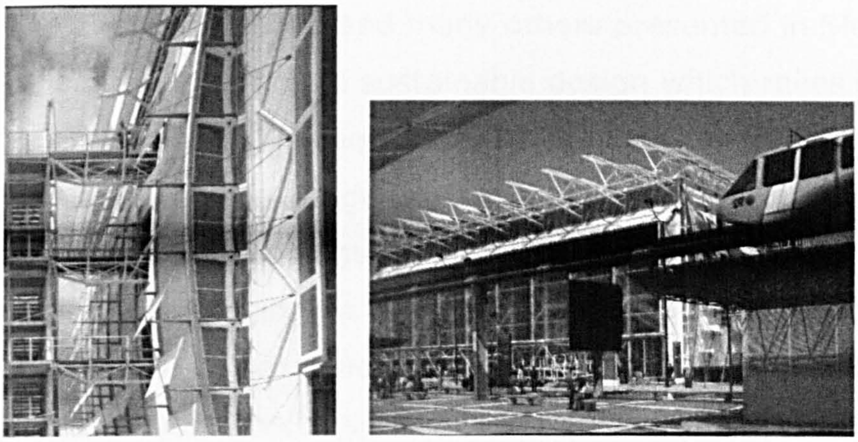
Thinkers such as Langdon Winner, who warn about the unforeseen consequences of technological ideology, claim, contrary to Ortega, that technology is difficult to restrict or control once its influence on society has become as immense and complex as it is today. According to Winner, once people have adopted certain conveniences provided by technology, their expectations about what the good life should include change respectively (Winner, 1999: 3). Through the process of incorporating technology into our daily lives, we change not only our habits and ways of action but also our expectations and desires. In this sense, technological ideology reinforces itself, not only through high-level political decisions but through people's daily activities.

Some may even argue that people are left with not much choice other than cooperating with the technological ideology which pervades society. Karl Jaspers referred to a "technological apparatus," consisting of workers, machines and bureaucracy, which organises and determines the way daily social life are being carried out. Jaspers' technological apparatus leads to what he calls "mass rule," which is a system of mass production that fosters homogenisation of the material environment in which humans live, and which approaches humans not as unique individuals but as fulfillers of functions (Verbeek, 2005: 18). Jaspers' "technological apparatus" is maintained and sustained by the public as well as decision makers. Commitments made to technological projects through investments, for example, tend to be difficult to drop if any problems arise, so that the whole system becomes dependent upon technological progress in order to sustain itself.

It seems that Jaspers' "technological apparatus" is increasingly capable of applying more techniques and investing more money in sustaining its own ideology. As people continue to cooperate and purchase new technological products and systems, so does the propaganda to support the prevailing way of life grows. The marketing for technological acceptance ensures that people are less able to freely choose their own way of life and are instead manipulated into believing in the necessity of the technological ideology for future human comfort and development.

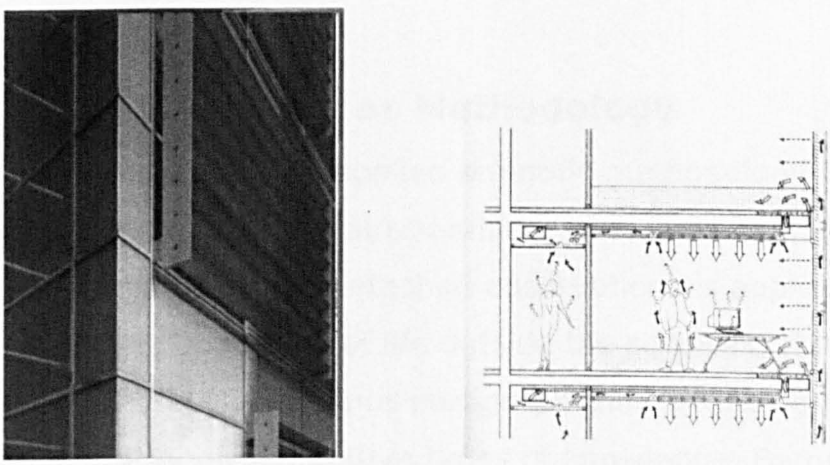
From the point of view of sustainability and sustainable architecture, it can be assumed that the tendency to search for technological solutions to environmental problems stems from the ingrained belief in technological ideology and the power of technology to cure any problem which may arise. In fact, the tendency to view environmental issues as "problems" in the first place stems from a technocratic point of view. Environmental issues are viewed as "problems" because they threaten the very base of the scientific and technological ideology of human dominance over nature. Environmental issues are therefore approached as if they were a "loose screw" in a larger machine; they must be observed, as if they were a scientific problem, and fixed as soon as possible, before they may endanger the existence of the entire technological system.

In architecture, technocratic approaches to sustainable solutions are exemplified in books such as 'Eco-Tech' by Catherine Slessor (1997), which offers a view on a variety of projects which employ new technological solutions to solve environmental problems in buildings. One of the projects described in the book is the British pavilion in Seville, designed by Grimshaw and Partners. The building is described as a "paradigm of environmental experimentation, proving that ecological concerns and High-Tech architecture are not mutually exclusive" (Slessor, 1997: 88). The steel and glass pavilion uses a range of unusual cooling devices, such as a giant water wall and water pumps generated by solar panels, as well as utilising boat-building technology to construct bow-string trusses and translucent membranes.



Images 8+9 - British Pavilion by Grimshaw and Partners, Seville, Spain, 1992

An additional project presented in the book is The Microelectronics Park in Duisburg, Germany, designed by Foster and Partners. The project incorporates a "highly sophisticated building management system which analyses current and anticipated weather conditions to calculate the optimum levels of heating, cooling and shading, and by adjusting horizontal lattice blinds in the triple-glazed external skin, occupants can fine-tune the temperature and light in their own spaces. The responsiveness of the system sets new standards for environmental control" (Slessor, 1997: 92)



Images 10+11 - Sun Reflector and Environmental control system in Microelectronics Park, designed by Foster and Partners, Duisburg, Germany, 1996

The examples above and many others presented in Slessor's book reflect an approach to sustainable design which relies on technology as an ideological framework to solve environmental issues in architecture. The danger with this approach is that it tends to retain the belief in technology as the only solution to pending problems, rather than adopting a more comprehensive view. Some high-tech sustainable devices and systems may offer very innovative and valuable solutions, which can and should be applied when they are appropriate within a specific context, but there is a danger in current tendencies to 'blindly' adopt such high-tech sustainable solutions to buildings as sole indicators of sustainability.

Instead of blindly adopting such high-tech solutions (generally based on an ideological belief that technology can solve all problems), it may be more adequate to examine the *type of relationships* that such technological solutions offer between users and nature. Does the design solution promote interdependence between the user and nature? Does it promote or block engagement with natural processes? These are the type of questions that may be useful to ask in order to promote a more ecological architecture.

12.2 Technology as Methodology

Technology as applied scientific methodology is the way in which the technological/scientific way of looking at the world and analyzing it through detached observations is applied to other disciplines and areas of life outside the sciences. It has been discussed in the previous paragraph that technological ideology rejected 'illogical' intuitive types of knowledge. Bergson defined the difference between intuition and analysis as the difference between grasping the unknown and relying on familiar representation;

> An absolute could only be given in an *intuition*, whilst everything else falls within the province of *analysis*. By intuition is meant the kind of *intellectual sympathy* by which one places oneself within an object in order to coincide with what is unique in it and consequently inexpressible. Analysis, on the contrary, is the operation which reduces the object to elements already known, that is, to elements common both to it and other objects. To analyze, therefore, is to express a thing as a function of something other than itself. All analysis is thus a translation, a development into symbols, a representation taken from successive points of view from which we note as many resemblances as possible between the new object which we are studying and others which we believe we know already (Bergson, 1912: 23-4).

Bergson suggests that by rejecting intuition and applying solely scientific analysis as a methodology for understanding the world, we are actually "giving up" an attempt to grasp the essence of the unknown by turning to comparison of the 'unknown' with already familiar phenomena. This method of accumulating data and knowledge is otherwise known as *induction*. According to induction, "one starts with observations of individual cases, and uses these to predict future cases... Induction generalizes from individual cases to laws. The more individual cases that fit a generalization, the more probable the generalization" (Dusek, 2006: 6-7). It is clearly expressed from the above quotation that the process of induction is a process which is dependent on its own continued manifestation in order to be able to work. Hume was the first philosopher who acknowledged this as "the problem of induction" - he pointed out that the reasoning from past success to future success is in itself an inductive inference and it depends on the principle of induction! Hume's problem exemplifies one problematic aspect of the scientific method, which is the apparent dependence of scientific experiments on one another in order to be able to refute a law. Kant subsequently observed that structure found in nature as a result of scientific induction is dependent on the structure of our minds, so that what we observe is a result of our thinking and not of 'objective' truths which are present in the outside world (Dusek, 2006: 8). Although these controversies regarding the major scientific method of observation - induction - existed from the very beginning of the technical-scientific legacy, most scientists did not regard them as an obstacle to their continued work.

One of the major criteria for acceptance of scientific "truths" is the 'verification theory of meaning', according to which, for a statement to be meaningful it had to be possible to verify it (Dusek, 2006: 8). It is easy to realize how through the process of induction and the verification method science could slowly build up a view of the world which seemed rational and objective, but at the same time excluding any possibility which was not quantifiable from existence.

An additional scientific method which largely affected other disciplines of thought was that of *deduction*. Unlike induction which generalizes from specific cases to general laws, deduction tends to break a situation down into isolated pieces and study the pieces separated from the whole. Deduction is a way of studying nature which allows the observer a possibility to focus on details in a microscopic level. Deduction is a very useful way of analysis, as long as the bigger context of the whole is not being forgotten or neglected. One of the biggest criticisms about the scientific method of deduction is that once the isolated part has been lifted out of its context it: (a) is no longer regarded as a part but is now viewed as a whole in itself, which is misleading, and (b) it loses some of its attributes which are only manifest when it is connected to the whole to which it belongs (Bohm, 1995). Scientific scrutiny tended, in most cases, to isolate the studied object from its context without regarding such separation to be problematic. This methodological tendency for isolation has come to dominate many other areas of studies outside the sciences, and is regarded by some to have had far reaching negative consequences on Western culture. According to Bohm, the most dominant world-view in the modern world has originated from the deductive scientific method of analysis.

> In essence, the process of division is a way of *thinking about things* that is convenient and useful mainly in the domain of practical, technical and functional activities. However, when this mode of thought is applied more broadly to man's notion of himself and the whole world in which he lives (i.e. to his self-world view), then man ceases to regard the resulting divisions as merely useful or convenient and begins to see and experience himself and his world as actually constituted of separately existent fragments. Being guided by a fragmented self-world view, man then acts in such a way as to try to break himself and the world up, so that all seems to correspond to his way of thinking. Man thus obtains an apparent proof of the correctness of his fragmentary self-world view though, of course, he overlooks the fact that it is he himself, acting according to his mode of thought, who has brought about the fragmentation that now seems to have an autonomous existence, independent of his will and of his desire (Bohm, 1995: 2-3).

The deductive methodology is highly prevalent in the sustainable design discourse as an instructive method for solving environmental "problems." Different types of performance threshold models, which assess the impact of a building against a range of criteria, are applied to evaluating a building's "greenness." These types of models are usually divided into categories which separately assess the building's 'environmental performance' according to different categories such as: building materials, energy consumption, land use, transport, pollution, water, management, health and well-being (for example see: www.breeam.org). These environmental assessments according to isolated categories may be useful as an initial method for understanding the various ways in which a building may affect the environment, but are ultimately limited in the long run because they maintain the separation not only between the building and its context, but also between the building systems themselves. For example, by calculating the embodied energy of materials[10] in isolation, the wider context of the building and the total energy needed for its operation is often neglected; "As buildings become more energy efficient to run, the embodied energy becomes a more significant percentage of the total. Conversely, the longer the life span of a building, the less significant the embodied energy becomes, making up a reduced percentage of the overall energy requirements" (Sassi, 2006: 182).

Various sustainability assessment methods may also turn out to be misleading at times. Whilst they are practically useful as an objective, measurable set of criteria for evaluating a building's sustainability, they may turn out to be subjective at times, and for that reason, also misleading. For example, the environmental profile methodology - a method designed to evaluate the environmental impacts of construction elements, by quantifying their impacts in terms of climate change, fossil fuel depletion, waste disposal, water extraction, etc. are subjective by definition, although they were agreed by a broad range of interested parties. In certain instances, for example, occupant health or local manufacturing support may be given more importance than global warming consequences (Sassi, 2006: 145).

Furthermore, these environmental assessments tend to isolate the means from the mission. As Wines remarks, while the 'mission' calls for a strong commitment by societies to connect to nature on a deeper philosophical and psychological level, the 'means' or incentives to do so are manifested as a collection of remedial mechanisms which do not address the deeper environmental and

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[10] Embodied energy is the total energy required to manufacture as well as transport materials (Sassi, 2006).

social issues (Wines, 2000: 11). Therefore, the attempt to address environmental issues by technical methodologies may not be the best way to ensure a long-term integration between people and nature.

12.3 Technology as a Tool

The discussion about technology up to this point has examined the role of technology as applied scientific ideologies and methodologies, which have co-shaped modern western cultural thinking, starting from the 16th century until today.
But what role do technological tools and devices themselves, as hardware, play in the formation of culture? How do they influence our daily lives, our behaviour and attitudes toward nature? These questions will be explored in the following discussion in order to gain a better understanding of the role that technology plays, as a physical manifestation in buildings, on people's relation to nature.

'Technological determinism' is an approach to technology which claims that technological tools themselves, once implemented within society, take part in shaping the structure of that society. According to technological determinism, as technology develops and changes, so the institutions, the arts, and the religions in the rest of society change. For example, the invention of the computer has caused a major change to the way we work and educate ourselves. The telephone and later on the internet have completely changed the nature of interpersonal communication (Dusek, 2006: 84). On the other hand, technological determinism critics claim that society does have an effect on the acceptance or rejection of technologies. One way of proving this is by showing that alternative directions to the development of technology were available and that a socially influenced choice was made. This is often difficult to do, as Dusek points out, since "once a technology has been settled on it acts as a constraint on further directions of development. The technology then appears in retrospect to be inevitable, and this supports the belief in technological determinism" (Dusek, 2006: 99). An additional problem with the claim that society controls the direction in which technology develops lies, according to Ellul, in the fact that nobody seem to understand fully the complexity and consequences of the technological system;

> While the technologists are generally ignorant and naïve about the social and political issues surrounding a technology and the politicians are often abysmally ignorant of the workings of the technology itself, Ellul claims that the public is ignorant of both the technical and the social aspects of the technology (Dusek, 2006: 105-6).

Supporting the social complexity which underlines the technological system but opposing its autonomous technological nature, the social constructionists claim that a technological artefact is composed only of the totality of meanings attributed to it by various social groups. In other words, social constructionists attribute no importance to the concrete physical technical device, but only to its constructed meaning and evaluation by various social groups. Some thinkers in this field include Bijker, Pinch and Latour (Sismondo, 1993). Some regard the social constructivist view to be problematic, arguing that they ignore the fact that technology is mostly dominated by an elite group of managers and politicians, which leave no room for the interpretations and desires of the labourers (Winner, explained in Dusek, 2006: 206). Once the dominant group gains control over the use and application of the technology, then technology can easily be regarded as 'autonomous', since people can rarely reject it. The consequence, then, is that "technological inventions tend to unfold automatically from the nature of the world and the nature of scientific method. Thus technology can be claimed to have a logic of its own, independent of human desires" (Dusek, 2006: 106).

In the domain of environmental products and services, the autonomous nature of technology is well manifested. As Manzini observes;

> The great, and in many ways tragic, discovery of this period is just this: the boomerang or rebound effect by which actions expected to have environmentally positive effects, in fact bring insignificant, if not actually negative results. And technological improvements, meant to improve the products and services eco-efficiency, for reasons that are rooted in the complexity of the overall socio-technical system, seems "naturally" to become new opportunities for consumption, i.e. increases in the system unsustainability (Manzini, 2003: 4).

As Manzini suggests, technological products and services themselves, even if transformed to be more sustainable, do not contribute much to environmental performance unless they come alongside a deeper change in both the behaviour of people (consuming less and requiring less services), and the overall complexity of our cultural system which still supports a certain (technological) way of life.

According to Manzini, if we move from a consideration of every single product to a consideration of the system as a whole, we realize that the overall consumption of environmental resources continue to increase. Manzini refers to this phenomenon as the "product-based well-being," which identifies the problematic nature of the overall technological system that supports consumerism and the proliferation of products, whether environmental or not. One possible solution is the transition to an "access-based well-being," as Manzini describes it.

> Well-being no longer appears linked to the acquisition of a "basket" of material products, but rather to the availability of access to a series of services, experiences and intangible products. More specifically: in a society saturated with material goods, to focus on the immaterial seems more interesting (Manzini, 2003: 4).

As reasonable and seductive as the transformation to an "access-based well-being" may seem, Manzini supposes that the transition from products to services is not sufficient in itself to solve environmental problems, which stem from deeper, un-sustainable systemic patterns. The reasons that he suggests for the failure of "access-based well-being" are:

1. The new intangible needs tend to be added, and not substitute, the old material ones.
2. The speed and flexibility of new life-styles imply the same speed and flexibility in access to services which, for this same reason, proliferate.
3. Services and experiences, per se, may be immaterial, but their delivery may be highly material intensive (Manzini, 2003: 5).

Manzini's conclusions suggest that neither environmental products, in themselves, nor a transition from products to services can make a significant contribution to sustainable behaviour. A much grosser and deeper systemic change is needed in people's own perceptions and attitudes towards nature, society, and cultural values (Manzini, 2003).

In terms of the more personal relationship that exists between people and technological tools, there are several views about the effects of new technologies on our general well-being and wider connection to nature. Naess argues that when a certain technique is replaced by another which requires "more attention, education, and is otherwise more self-engaging and detached, the contact with the medium or milieu in which the technique acts is diminished. To the

extent that this medium is *nature*, the engagement in nature is reduced in favour of engagement in the technology" (Naess, 1989: 103). Naess supposes that as a result of engaging more with technology instead of nature, our degree of attentiveness and awareness to changes in nature is diminished. Therefore, increasing human engagement with technological tools and systems can be viewed as an additional cause of environmental degradation.
Mass industrial production is also viewed by some as a fuel for environmental problems, since it curtails the attachment between humans and the world around them in two significant ways: (1)humans no longer participate in the production of artefacts personally (as the makers of their tools), and (2)the finished functional, standardized artefacts are no longer valuable for humans as individual objects, and can be easily replaced by similar functional copies (Verbeek, 2005: 23). This lack of personal connection between people and their artefacts encourages increased consumerism (to constantly satisfy unsatisfied needs) and proliferation of waste-products.

It can be concluded form the above discussion that solely focusing on the design of individual environmental products and technologies may not solve environmental problems, although it is certainly a step forward from the continuous use of environmentally-harmful products and technologies. Still, the role of technologies and tools in promoting environmental behaviour may lie not only in their physical environmental impact, but also, and maybe even more importantly, in the type of relationship that they promote between people and their environment. What do these products teach us about the environment? Are they meaningless or do they carry an added value for us? Do they allow us to relate to our surroundings in a new way? These are the type of questions that designers need to have in mind when designing 'ecologically,' and the ecological principles may be of help in guiding such inquiries.

12.4 Conclusions

The prevailing attitude to technology within the sustainable design discourse is contradictory on a number of levels. On the one hand, there is an ingrained tendency within society in general to view most issues from a linear-technocratic ideological point of view, and environmental issues are no exception. Therefore, the suggested solutions to environmental problems within the building industry are manifested in a series of guidelines and restrictions for making buildings more environmentally benign. Technological-rational methodologies are applied as viable solutions in the form of various assessment methods and performance criteria. The application of these methodologies as rational solutions to environmental problems within the building industry extends the already existing distinction between nature and culture, instead of attempting to bring them closer together.

Similarly, the fascination with technological tools and systems is also evident in current sustainable design solutions, which aim to replace 'wasteful' and 'harmful' technological artefacts and systems with 'clean' and 'efficient' sustainable artefacts and systems. The result is already evident in the form of sustainable products simply replacing unsustainable ones. This may be a welcomed change for society in a direction of a less environmentally-damaging lifestyle, but it does not ultimately lead to a deeper change in our way of thinking about the world, which is necessary if we wish to achieve a re-integration between people and nature. A fundamental change to an overall destructive, consumptive technological cycle seems to be impossible to achieve as long as 'sustainable' actions are performed within a technocratic mindset.

13. General conclusions from Section Two

The discussion about sustainable architecture within the three different chapters reveals the following:

1. The contradictory relation to nature, ranging from fear and need for protection, through nature-conservation strategies, and all the way to systemic inspiration from complex natural structures, leads to a range of different sustainable architectural solutions. Most of these solutions tend to promote a continued distinction between architecture and nature. This leads to a realisation that in order to fundamentally change the way humans relate to nature through architecture, designs should enable people to re-connect and re-inhere in nature not only practically or theoretically, but also *experientially.*
2. The confusing role of the user within sustainable architecture, ranging from viewing the user as an obstacle for sustainability in buildings, to user-integrated solutions and user-participation in the design process, it becomes clear that in order to promote inherence with natural processes, users must become integrated into design considerations, as their experience and interaction with nature, through the building, is essential for achieving long-term sustainability.
3. The technological-dominated approach to sustainable architecture becomes apparently problematic, as it promotes a detached and very controlled relation to nature. Perhaps by exploring possible human-nature interrelations, based on ecological principles, a more relational and less controlled approach to sustainable architecture can emerge.

13.1 Utilising the ecological principles to inform the conceptualisation of sustainable architecture

In order to proceed by utilising the ecological principles discussed in the previous section of this thesis, the interrelations between people and nature will be explored, by regarding technology as the interface between them, which enables those relations to occur. In the context of architectural design, architecture will be regarded to represent this technological interface.

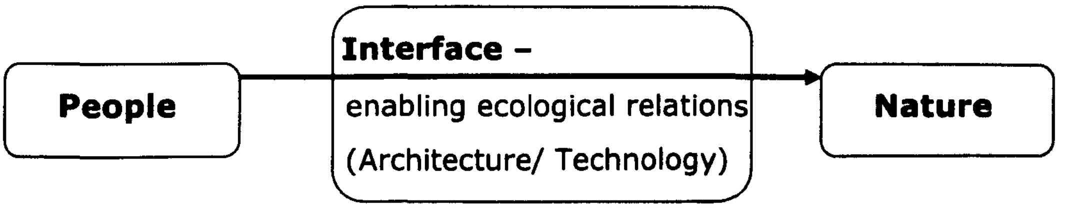

Diagram no. 4 - People-nature interface

The ecological principles from section one are divided into three overarching principles:

1. The relation between the part and the whole in ecosystems.
2. The relational dynamics between the components themselves.
3. The phenomenon of growth - emergence.

1. Part/Whole Relation

Looking at sustainable architecture through the lens of ecological relations entails blurring the distinction between people and nature through the interface between them (in this case, this interface is architecture). This can begin by acknowledging the interrelations between part and whole. A distinction between part and whole must

initially be established. In this case, it is useful to regard the user as the part and nature as the whole, since nature provides the bigger context for the user's existence. This distinction will also enable a re-integration of people with nature. Therefore, the part/whole relation can be defined as the relation between people (the users) and natural processes in the environment (viewed as the bigger context for human existence).
The defining principles for the part/whole relation are: Interdependence, Purposefulness and Autopoiesis. Together they suggest that the relation between the part (user) and the whole (nature) is a relation of interdependence and correlation in purposes which lead to an overall autopoietic system, i.e. a system which can constantly recreate itself through the relations between its components. It is suggested that architecture, as the interface between people and nature, may be able to support an ecological relation between people and nature by becoming a platform on which interdependencies and correlations between people's behaviour and natural processes on site are manifested.

2. Relational Dynamics

Relational dynamics describe the ongoing interdependent relations that exist between agents within an ecosystem. In the context of sustainable architecture, relational dynamics suggest that the relationship between people and nature, as it is enabled through the architectural environment, is a relationship which is constantly changing, and its dynamic nature should be expressed through the architectural interface. This implies that static regulations aiming to minimize architectural inputs and outputs to the environment essentially do *not* support such dynamic relations. Instead, an architectural platform, which encourages constant exchange and feedback between people and natural processes may be more appropriate to support such dynamic ecological relations.

3. Emergence

The idea of emergence describes a process of growth in ecological systems, where new organisational levels can emerge that are generally more complex than previous levels. In the context of sustainable architecture, the idea of emergence describes an architectural environment that can grow and evolve with time. This entails that the initial architectural structure is only a base platform from which more complex architectural configurations can emerge, over time. By enabling constant, dynamic interactions of people with natural processes to take place on site, the architectural environment becomes open to unpredictable situations, which may transform the existing architectural structure.

In order to promote ecological relations between people and nature as part of the architectural environment, it is important to ensure the transparency of the process. In other words, the technology employed as part of the architectural environment must be accessible to as many users as possible in order to encourage their engagement, and to promote continuous feedback relations between people and natural processes. The ecological principles and their possible manifestations in architecture will be further explored in the next section.

14. Introduction to Section Three

Introducing ecological principles into the sustainable architecture discourse may open up a possibility to 'expand' current prevalent conceptions of architecture; from those which focus on the physical structure of the architectural system to a conception which encompasses the architectural system's relations with its environment as part of its definition as a system[11].

This may entail that instead of referring to some processes, such as users' interactions with architecture, and natural processes in the environment[12], as external to the architectural system, and therefore, as dispensable, in terms of their affect on the design of the architectural system - they can be integrated into the initial design considerations of the architectural system and inform it.

Understanding the behaviour of ecological systems, according to the principles which were introduced in section one, opens up a possibility for designers to understand natural systems from an ecological point of view – a point of view which stresses their dynamic, relational and interdependent nature. This ecological point of view on natural systems extends to encompass an understanding of human interactions and the way in which human interactions are influenced by their surrounding natural environments[13].

Within the context of architectural design, it is suggested that the ecological principles explored in section one can guide a process of

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[11] It may be appropriate here to define an architectural system by referring to Ackoff's definition of systems, as "a set of interrelated elements... an entity which is composed of at least two elements and a relation that holds between each of its elements and at least one another element in the set. Each of a system's elements is connected to every other element, directly or indirectly" (Ackoff, 1971: 662).

[12] Environment refers to the set of elements which are not part of the system in question, but a change in any of which can produce a change in the state of the system (Ackoff, 1971: 663).

[13] For more information on this subject see: *Human Ecology: problems and solutions* by Ehrlich, 1973.

analysis of users' interactions with natural processes, and the way in which the design of the built environment can support more beneficial, ecological relations between people and nature.

This ecological, relational point of view on the relationships that the architectural environment affords[14] suggests that architecture is no longer viewed as a *static object* within its larger context, but rather as a *dynamic, relational and interdependent system*, that exhibits similar relations with its environment to those that ecological systems exhibit. The reason for this change in perspective is due to the fact that architectural systems *do* exhibit interdependent relations with their environments over time, and it is mistaken to perceive them as static objects in relation to their environments. Architecture exists in a context, and this context is inherently alive, dynamic and constantly changing; whether it is a cultural, social context or whether it is a natural context. The fact that architecture is part of a live context - meaning that it is created *from* that context and ultimately dissolves *into* its context, means that it is part of it, and therefore should be considered "alive" as well. Perceiving and defining architecture as a static object, a one-off creation, entails that architecture is, in fact, being disconnected and lifted out of the live context of which it was initially a part. Instead, perceiving and defining architecture as a live ecological process, gives it a better chance to remain an inherent part of its context, and also enables it to contribute to that context on a continual basis, rather than as a one-off occasion in time.

Therefore, it is the aim of the discussion in the next section to begin to inquire into the possible applications of the ecological principles described in section one to the conception of architectural systems.

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[14] 'Affordance' is a term first introduced by J.J. Gibson in 1977 and refers to the quality of an object, or an environment, that allows an individual to perform an action (Gibson, 1979).

The application of the ecological principles into architecture will be attempted systematically. This entails that each one of the ecological principles discussed in section one will, in turn, be investigated within the context of architecture, and its possible interpretations and implications on the conception of architecture as a dynamic system of relations, between people and nature, will be explored. The proceeding investigation of the ecological principles within the context of architecture will be conducted as a propositional inquiry. The proposition that will be brought forward in the following section is that ecological principles *can* expand the conception of architecture; from that which is based on the conception of architecture as an object within the environment, to that which is based on a conception of architecture as a process of relationships within the environment.

The application of ecological principles into different fields has already been previously acknowledged[15], but it may be useful to reintroduce one of the examples in order to illustrate the possible implications of introducing ecological principles to other fields.
In her propositional model for education, which is based on several ecological principles, Keiny (2002) chose to redefine the educational system as a system of interacting sub-systems. This proposition enabled Keiny to transform the conception of education from that of a rigid, self-contained system into a more dynamic system, composed of inter-related sub-systems. The definition of the sub-systems within the educational system, according to Keiny's model, can change in accordance with the context in question. In certain socio-economical contexts, it may be appropriate to include local industry, for example, as a sub-system for education, while in other instances, it may be more useful to include the internet as an integral educational sub-system. The definition of the sub-systems in

[15] See in the introduction to section one on p.26

Keiny's ecological-educational model is flexible according to the context of the educational system. The important contribution of her propositional model was in breaking the boundaries of the prevalent conception of the education system in Israel, by introducing a variety of possible alternative sub-systems that can be incorporated into the educational model, depending on varying contexts and needs.

Similarly, by introducing ecological principles into architecture, it may become possible to break the boundaries of the current prevalent conceptions of architecture to include processes that may have previously been perceived as 'external' to the architectural system, just as Keiny chose to include industry as a sub-system of education, and external researchers as another sub-system. This integration of 'external' systems into the educational system enabled an expansion and 'opening-up' of the education system to 'outside' forces.

Leading from the previous discussion, the proposition that will be brought forward in the following section will aim to investigate how ecological principles can be applied to the possible relations between people ('the users') and natural processes through the architectural system. In this sense, it is hoped that the conception of the architectural system can be extended to incorporate users' experience and natural processes in the environment.

15. Applying Ecological principles to Architecture

The investigation of ecological systems' organisation in section one has revealed a number of common principles, which provide an overview of basic developmental patterns of natural living systems. These ecological principles, once explored in relation to existing architectural theories, may provide some insights into how architectural systems can be designed to support similar ecological relations between humans and natural processes in their environments.
It has been argued in the second section of this thesis that current sustainable design discourse, which is based on the notion of 'sustainability', offers a confusing and sometimes contradictory array of solutions to some environmental and social problems which the architectural design discourse is faced with. It is the aim of the following section to begin to formulate an understanding of the ecological principles within the context of architecture, in such a way that these principles may expand current notion of 'sustainability' to include a more dynamic, flexible, and relational framework for ecological architecture.

15.1 Science and Architecture

An attempt to borrow concepts from the science of ecology and apply them to architecture must take into account previous similar architectural approaches, understand where they failed and attempt to avoid repeating similar mistakes.
Attempts to borrow scientific concepts and apply them to architecture have been made throughout the history of architecture,

as early as Vitruvius, and continue until today. Many of these attempts were successful in offering new design methods, and creating new relations between architecture and other areas of contemporary culture. Architects, wishing to make their architectural practices legitimate, naturally turned to science in search for answers. The consequence of these attempts were that in order

> for architecture to approximate to a scientific practice it was necessary to be able to isolate and abstract specific features or properties from the complex phenomenal reality of the built work, and to subject those abstractions to independent analysis (Forty, 2000: 92)

Therefore, the immediate, experiential relationship that may have existed between architects and their designs, gave way to a new analytical, observational relation. This continuous process of architectural observation and detachment, which originated with the search for an ultimate architectural scientific "truth," has slowly obscured the fact that architectural design is ultimately not an exact science (in the same way that engineering is, for example) but only borrows concepts from science as metaphors for its designs. As Forty explains;

> The characteristic of an effective metaphor is that it borrows an image from one schema of ideas, and applies it to another, previously unrelated schema. Metaphors are experiments with the possible likenesses of unlike things. Each one of the countless scientific metaphors in twentieth-century architecture is a little experiment, an attempt to find a relationship between architecture and one or another branch of science, but they all rely on our belief that really, at the bottom, architectural practice is not scientific (Forty, 2000: 100-1).

Forty's distinction between architecture and science is important for the realisation that architecture is embedded in every-day life in a way that science is not. While science is an attempt to make distinctions about world phenomena through detached experimentation and observation, architecture cannot detach itself from the context and reality of which it is part. This may have been the main failure of many architectural theories which attempted to make architecture "scientific" by detaching it from its context and ignoring its immediate connections with the surrounding every-day reality.

This discussion must begin with the realisation that it is not the aim of this research to arrive at an abstract definition of architecture as a metaphor for an ecological system, but rather is an attempt to re-connect architecture to its immediate context, which includes natural and social systems, and to do so by drawing parallels to ecological systems, in light of their inter-relational nature, and for the fact that architecture is embedded in them.

15.2 Ecological "laws"

One of the first points to be clarified in this discussion is that a theoretical architectural framework which rests on ecological principles does not aim to provide a prescription for design. This type of theory does not rely on certain laws, which are to be applied literally from one discipline to another. It is more similar in its essence to some search for truth rather than a quest for certainty. Beautifully observed by Dillon, the difference between a search for truth and a quest for certainty can be described as follows:

> The search for truth is an attempt to pierce the opacity of the world, an effort to make our conjectures about the world as accurate as possible. The quest for certainty, on the other hand, is an attempt to eliminate the opacity of the world altogether and make it entirely transparent; an essay to expel all conjecture or supposition from our knowledge (Dillon, 1988: 10).

In the context of this discussion about ecology, it is important to observe that "ecological" principles do not offer certainty in the form of distinct 'Laws of Nature', according to which ecological systems always manifest themselves. It is rather a broader understanding, or insight, into the behaviour of ecological systems, which was barred to ecologists until recently, exactly because they tended to look for certainties instead of general commonalities. This misconception within the study of ecology and the search for 'ecological laws' started "from the suggestion that ecology as a science should model itself on physics, and as part of this imitation, it should develop its own laws of nature. The logic behind this seems to rest on the observations that physics is successful, and also that it has Laws of Nature. From these observations it is deducted that it is the laws that make physics successful, and hence that other sciences (in particular ecology) which do not have laws cannot be successful" (O'Hara, 2005: 390).

This search for 'ecological laws' began to dissipate during the 1970's when new experimental work in plant pathology proved that the development of simple predictive models based on growth and dispersal patterns can be highly effective in reducing plant infection, without relying on any laws (O'Hara, 2005: 393). These experiments and others have opened the path for ecologists to be content to look for broad generalisations, from which models can be induced, which will then be applied to work for specific systems. In the same way, when we search for ways to apply the ecological principles to architectural design, we should avoid applying the ecological principles as 'laws' and instead search for ways to generalise the principles into a coherent system, which can then be applied differently in each context.

15.3 The Advantages of the Ecological Model

It may prove beneficial to initially explore why a theoretical ecological model, which is based on ecological principles, seems appealing not only to architecture, but at the same time to so many other disciplines outside the scientific discourse.

It seems that in today's world where change permeates everywhere and conditions don't seem to stay stable for very long, a theoretical model such as the ecological one can offer an alternative way of thinking about the world. Unlike the Cartesian world view which encompasses a stable, entity-based model of reality, the ecological model allows an understanding of the world as a dynamic system, which consists of many other systems that constantly overlap, grow, change and proliferate.

Instead of contrasting order with chaos, as the Cartesian model often does, the ecological model encompasses both. It does not dismiss the chaotic nature of the world as "uncontrolled mess" but instead is in a continuous search to try and find order within that apparent chaos. Ecological modeling is an attempt to map complex dynamic natural systems and derive organisational conclusions from their apparent chaotic behavior (Bossel, 1998). The complex and apparently chaotic nature of living systems is a feature which is worth studying and understanding not only because it enables humans to better understand ecological living systems, but also because it opens up possibilities for applying similar complex structural models to other spheres of cultural and social organisations[16]. Living systems' complex organisation tends to indicate

> the capacity of the organism in question to survive in a wider range of environmental conditions than less complex organisms could accommodate. It tends to

[16] See several examples of such applications of ecological modelling in the introduction to section one p.24-27

> indicate the capacity of an organism to utilize resources, make the most of opportunities and get out of trouble (Mathews, 1991: 122)

It therefore becomes apparent that the higher the complexity of a living system, the higher its capacity for survival. A complex ecological model, applied appropriately to a different type of organisation, may induce a higher capacity within that organisation to endure a variety of circumstances.

Ecological modeling shifts the focus from objects to relationships, since it encompasses an understanding that objects are in themselves made up of relationships[17] (Capra, 1997: 37). This shift in focus from objects to relations opens up a possibility to consider new connections, rather than excluding certain opportunities for relations beforehand because their 'objective' stances do not correlate. In an ecological model, where relations are the priority, new combinations between previously unrelated domains become more plausible.

The ecological model, then, has the advantages of: encompassing change, through the capacity of its agents to adapt quickly; enduring different circumstances; as well as allowing apparent contradictions to exist side by side. The compatibility of certain systems or components to one another is not determined beforehand, but is rather determined through a process of feedback relations, which "steer" an ecological system in the desired direction (which best fulfills its purposes). Therefore, the ecological model allows different points of view the possibility to exist side by side without contradicting one another. This type of model, if applied to social or political organisations, has the potential to offer a striking alternative to currently dichotomic models (Spretnak, 1997), so that instead of observing problems through a 'black or white' lens – they can

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[17] This notion is also based on *String theories* (see: *The Elegant Universe*, Greene, 2000).

instead be observed through a wider range of colors that express the complexity of each situation in its context. Gare describes this possibility as a "polyphonic political grand narrative;"

> A polyphonic grand narrative would have a rhizome structure and represent a great diversity of perspectives, allowing all these to challenge each other so that whichever one was taken to be the most promising would be taken so only provisionally, on the assumption that it would be open to further challenges in the future. It also would be assumed that people in their everyday lives would be included as participants in this narrative and would be free to challenge it and participate in its reformulation (Gare, 2000: 211).

The ecological model can justifiably be described as an inclusive model rather than exclusive. It acknowledges simultaneously the importance of the individual part as well as the bigger whole, the local and the global, the organised and the chaotic. But its all-inclusive nature can also pose certain problems, such as the need to create boundaries, to distinguish between properties and to make sense.

Similar models to the ecological model, such as Deleuze and Guattari's idea of the *Rhizome* (1988), which describes an "acentered, non-hierarchical, nonsignifying system without a general and without an organising memory or central automation, defined solely by a circulation of states" (Deleuze & Guattari, 1988: 21), offer a view of a web-like structure that can connect very different types of entities and systems to one another. The appeal of the rhizome concept is that it is not composed of rigid units but of dimensions, or "directions in motion." It is not dependent on a beginning or end point but can connect to any other point from the middle, which is why they describe its components as 'milieus' (Deleuze & Guattari, 1988: 21). Deleuze and Guattari's rhizome concept may sound seductive but it remains highly abstract and lacks intentionality. In the rhizome concept, there is no mention of a context or direction to the system, which is what the ecological model offers *in addition* to the systems' complex structure. It may be true that directions and processes are better concepts from which to begin to construct a new relational connection between culture and nature, and Deleuze and Guattari's attempt to offer a concept that will unify organic and non-organic life is important. But how viable is it to describe a world with "no beginning and no end, only milieus?" A world which seems to have no attachments except for ones which are in constant flux?

The ecological model, unlike the rhizome, offers a complex, flexible organisation which is also grounded in a context, and can therefore suggest a continuity, a capacity for evolution in relation to a specific historical grounding.

For this main reason, the application of the ecological model to different disciplines must include an understanding of *contextual relations*. For if the ecological model opens up an opportunity for new combinations to be made, which are based on dynamic activity, then the focus can no longer remain on *entities* but must shift to *implications of relations* (Bennet, 2004: 365).

The importance of relations within the ecological model has been discussed in relation to ecology in section one, but when we come to apply the ecological model to other disciplines, we must formulate an understanding of relations within the discipline that we are referring to.

15.4 Ecological Relations in Architecture

Consideration of the significance of ecological relations within architecture entails shifting the focus away from the built form as a stand-alone object to the relationships that it enables between people and the already existing context.

Architecture is never built in a vacuum, it is always an addition to an already existing environment, be it natural or urban, and after its erection it changes the environment in which it was situated, and creates new relationships between people who come to occupy it or use it and this environment. Shifting the focus away from the building as an object to the building as a set of relationships that it enables, between people and the existing environment (which is now transformed by the building), may open up a new, "ecological" way of thinking about architecture.

The use of high-tech, 'smart' materials and systems in buildings are often seen as a way to transform the building from a static object into a dynamic, interactive "organism" which is able to 'respond' to its environment. These high-tech material components and systems that compose the building are often analogous in their function to skins, nerves, digestive, respiratory and blood supply systems. The result is a building 'entity' which behaves *like* an organism (Gage, 1998: 81). The problem with this type of approach is that it preserves the old Cartesian focus on entities rather than shift the focus to relations. The architectural system is defined as a building, an object, an entity, with the only difference being that this object now derives its inspiration from organisms.

Similarly, various sustainable approaches, such as those introduced by architects like: Norman Forster, Richard Rogers, Ken Yeang, and others, which seek to focus on the relations of the building with the natural environment, in terms of the building's inputs and outputs in relation to nature, still maintain the Cartesian focus on the building as an object, although its relation to nature might be taken more seriously under consideration. The focus, in these approaches, is not on new relationships that might open up between people and nature (through the building, as a new imposed presence on the already existing environment) but rather the focus remains on the building itself, as a system, and its relationship to the natural environment. Again, there is the persistence of the building as an object, rather than its break-down into relationships, which is what ecology entails. In order to break the distinction between the building as an object and its context, it may be helpful to shift the focus from the design of the building itself to the design of relations, which the building enables. The building then becomes a *platform* on which relationships between people and the environment are constantly being performed, rather than remaining the main source of focus for designers, as an iconic entity[18].

Instead of focusing on ways to *reduce* the building's impact on the environment, we can use the building as a chance to *enhance* relationships between systems that make up the environment. Similar ideas were suggested in McDonough & Braungart's book 'Cradle to Cradle' (2002). For example, that outputs from buildings, whether in terms of materials or energy, can be utilised as inputs for other systems, either natural or technological. It is therefore the designer's challenge to consider the designed object not as an object but rather as a process, which can be reintegrated within the natural or technological cycles in the environment[19].

The aim of the following section will be to investigate how the architectural system may be conceived as a process of relationships between people and nature. In that sense, the focus of the discussion will be on the relationships that the architectural environment can support between people and natural processes. The ecological principles discovered in section one will provide a framework for analysing these relations between people and their environment.

[18] The persistent view of the building as an iconic object is illustrated in: *The Iconic Building* by Charles Jencks, 2005.

[19] See also discussion in section 10.2

Architecture as a platform for ecological relations		
Ecological principles		*Architecture*
Part/Whole	1. Interdependence 2. Purposefulness 3. Autopoiesis	How is the part/whole relation between people and nature manifested through architecture?
Relational Dynamics	4. Positional value 5. Feedback mechanisms 6. Homeostasis	How are relational dynamics between people and nature manifested through architecture?
Emergence	7. Holarchic organisation 8. Increasing complexity 9. Self-transcendence	How is emergence between people and nature manifested through architecture?

Table no.5 - Structure of Section 3

The above table illustrates the structure of section three, which will aim to examine the ecological principles and their possible manifestation in architectural environments, through examining the relations between people ('the users') and natural processes on site. The section will include an examination of each ecological principle in isolation, and its possible interpretation within the built environment. It will then proceed by section four, which will include a case study, and a summary of the possible interrelations and overlaps between the nine eco-principles, and the way in which they combine to form one interrelated system.

The proposition which underlines the argument in the following section is that if architecture manages to manifest some of the ecological principles proposed in section one, then the architectural system can be transformed from being conceived as a static object into a more dynamic system that can continue to evolve in a similar manner to an ecological system.

16. The principle of Part / Whole

The principle of part/whole describes the interdependent relation between any part within a living system and the system as a whole. In the context of architecture, the differentiation between the part and the whole is the initial stage when beginning the application of the ecological principles to architectural systems.
Since this thesis aims to examine the relation between people and nature, through the built environment, the definition of the parts will refer to people ('the users') while the definition of the whole will encompass the natural environment within the context in question. The building, or designed environment, then, acts as an interface between parts (people) and whole (natural context).
The ecological principles which help to define the relations between parts and wholes are: (1)Interdependence, (2)Purposefulness, and (3)Autopoiesis. Each one of them will be explored in turn in regards to its possible applications within the context of the built environment.

16.1 Interdependence between people and nature in the context of the built environment

The significance of the principle of interdependence in the part/whole relation within living systems is in stressing the mutual dependence of the agent and its environment on one another. The contribution of the agent to the development of its environment coupled with the fact that it is dependent on the environment for its existence is the manifestation of this interdependent relationship.
Within built environments, possible interdependencies between people and nature are less obvious than within natural living systems, and should therefore be examined.

16.1.1 People's dependence on nature

People's degree of dependence on nature may vary according to context. While in various indigenous communities around the world people can still be regarded to be highly dependent on their natural environment, in more "developed" urban settings people are less and less dependent on nature for their survival (Crowe, 1995). Viewed from a practical perspective, this notion may well hold true, although some may argue that at a more fundamental psychological and emotional level, there exists a basic human-ingrained need to affiliate with nature and natural processes, regardless of context[20]. The following table describes a typology of values, each is thought to represent "a basic human relationship and dependence on nature indicating some measure of adaptational value in the struggle to survive and, perhaps more important, to thrive and attain individual fulfilment" (Kellert, 1993: 59).

[20] See discussion on the "Biophilia hypothesis" in section 11.2

Term	*Definition*	*Function*
Utilitarian	Practical and material exploitation of nature	Physical sustenance/ security
Naturalistic	Satisfaction from direct experience/ contact with nature	Curiosity, outdoor skills, mental/ physical development
Ecologistic-scientific	Systematic study of structure, function, and relationship in nature	Knowledge, understanding, observational skills
Aesthetic	Physical appeal and beauty of nature	Inspiration, harmony, peace, security
Symbolic	Use of nature for metaphorical expression, language, expressive thought	Communication, mental development
Humanistic	Strong affection, emotional attachment, "love" for nature	Group bonding, sharing, cooperation, companionship
Moralistic	Strong affinity, spiritual reverence, ethical concern for nature	Order and meaning in life, kinship and affiliational ties
Dominionistic	Mastery, physical control, dominance of nature	Mechanical skills, physical prowess, ability to subdue
Negativistic	Fear, aversion, alienation from nature	Security, protection, safety

Table no.6 – A Typology of Biophilia values (Kellert, 1993: 58).

Kellert goes on to suggest that the above values' "cumulative, interactive, and synergistic impact may contribute to the possibility of a more fulfilling personal existence" (Kellert, 1993: 60).

If Kellert's assumptions are indeed true, and human fulfilment is dependent on the variety of relations we have with nature, then it follows that the more varied the possibilities humans have for interaction and engagement with nature and natural processes, the more chances they have for a fulfilling existence. If people's dependence on nature is indeed much more complex than a mere physical dependence (e.g. for air, light, water, food, etc.), then design considerations which aim to promote human well-being should extend beyond health considerations[21] to include as many possible relationships between humans and nature as possible.

16.1.2 Nature's dependence on people

The idea that nature is dependent on humans for its continued existence is highly contested. Most people would argue that while humans depend on nature for their existence, nature is by no means dependent on humans for its survival, as has been the case for millions of years, prior to human existence.

> Any serious attempt to deal with the harmful human impact on the global environment must take into account the fact that the species *Homo sapiens* stands in an asymmetrical relationship to nature and to the host planet Earth, even to the biodiversity which Earth supports. Thus, without the Earth's delicate life-support systems, we would have either to perish or be in a strategic position to shift to some distant but similar life-support system in space. But our own existence as a species is not necessary to the survival of the planet Earth.... By virtue of both our intelligence and the tools of dominance, we are an *emergent externality* to the very system which sustains us (Pandit, 2001: 299).

Although it seems plausible to assume that the earth will continue to exist even if the human race becomes extinct, the Gaia theory implies that human existence, by necessity, changes at least to some extent, the earth's regulation system[22]. It may therefore not come as a complete surprise if humans' impacts on the earth and on the natural processes that compose it prove to be more significant than were initially assumed. This is what James Lovelock argues;

> By failing to see that the Earth regulates its climate and composition, we have blundered into trying to do it ourselves, acting as if we were in charge. By doing this,

[21] See supplement 2 – *Designing healthy buildings* (Sassi, 2006).
[22] See the *Gaia hypotheis* argument in section 5.1

> we condemn ourselves to the worst form of slavery. If we chose to be the stewards of the Earth, then we are responsible for keeping the atmosphere, the ocean and the land surface right for life. A task we would soon find impossible - and something before we treated Gaia so badly, she had freely done for us (Lovelock, 2006).

Lovelock argues that human actions have interfered with Gaia's regulation mechanisms to a point of no return, and that this irreversible situation now implies that humans must take responsibility for restoring Gaia's balance;

> We are not merely a disease; we are, through our intelligence and communication, the nervous system of the planet. Through us, Gaia has seen herself from space, and begins to know her place in the universe (Lovelock, 2006).

Lovelock's argument suggests that the earth and the natural processes that compose it have, to a certain degree, reached a point of dependence on human actions for their (and our) continued survival.

16.1.3 Architecture as a tool for manifesting interdependencies between people and nature

It may now be asked whether or not architecture can become a tool with which people can reconnect to nature? Can it help manifest interdependencies between people and nature, in a way that both enhances natural processes as well as allows people to engage with them in various ways?

According to Norberg-Schulz, the existential purpose of architecture is "to make a site become a place, that is, to uncover the meanings potentially present in the given environment" (Norberg-Schulz, 1980: 18). He goes on to explain that meaning arises out of relationships with the environment;

> Man is part of a living world and does not conceive meanings in a vacuum. Meanings necessarily form part of a totality, which comprises natural components. Everything created by man is *in* the world, it is between earth and sky, and has to make this state of affairs manifest (Norberg-Schulz, 1980: 169).

It may follow, then, that one of the 'purposes' of architecture is to connect people to the natural environment on site, since this connection is what gives architecture its meaning through its relation to the existing context. Norberg-Schulz goes on to explain the concept of *gathering* which, according to him, implies giving natural processes a new, human form through abstraction;

> The concept of gathering implies that natural meanings are brought together in a *new* way, in relation to human purposes. Natural meanings are thus abstracted from their natural context, and as elements of a language they are com-posed to form a "new", complex meaning which illuminates nature as well as man's role within the totality (Norberg-Schulz, 1980: 169)

The problem with the concept of gathering, as Norberg-Schulz defines it, is that it interprets natural processes only in relation to human purposes, and by that it fosters the separation and distinction between people and nature instead of encouraging *inherence* of people in natural processes. There is therefore a contradiction between, on the one hand, the 'ability' of architecture to become meaningful through its set of relations to nature, and on the other hand, the process of distinction through gathering, by which humans abstract natural processes to re-combine them in relation to human purposes. It may therefore be more "environmentally friendly" to define a new gathering process for architecture, by which the purpose and design of the built environment is determined through a set of relations between humans and nature, that is based on an *integration* with natural processes rather than on their abstraction.

One of the difficulties in designing for integration with natural processes is the transition from the static conception of architecture into the dynamic realm of nature and its composing processes. As Rescher points out;

> Reality is at bottom not a constellation of *things* at all, but one of *processes*: we must at all costs avoid the fallacy of substantializing nature into perduring things (substances) because it is not stable things but fundamental forces and the varied and fluctuating activities which they produce that make up this world of ours. Process is fundamental: the river is not an *object*, but an ever-changing flow; the sun is not a *thing*, but a flaming fire. Everything in nature is a matter of process, of activity, of change (Rescher, 2002: 1).

The transition from viewing architecture as an object, which abstracts nature, into viewing it as a process, which is integrated with natural and other processes has already been discussed[23]. The focus of the argument brought forward in this thesis, however, is not on how to make architecture itself better integrated with natural processes, but on how to integrate people with nature *through* architecture. Architecture, then, becomes a tool through which continuous relationships between people and nature are being explored.

It is important, at this stage, to clarify what it may mean to use architecture as a "tool" for expressing interdependencies between people and natural processes. Mumford distinguished between tools and machines according to the level of engagement that they offer the user;

> The essential distinction between a machine and a tool lies in the degree of independence in the operation from the skill and motive power of the operator; the tool lends itself to manipulation, the machine to automatic action (Ingold, quoting Mumford, 2000: 300).

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[23] See section 10.2

A tool, therefore, enables a higher degree of freedom for the user in operating it, in comparison with machines. It has been argued earlier[24] that a high degree of environmental 'transparency' is essential for engaging users with built environments. This entails that in order for architecture to work as a mediator between people and natural processes, it must be designed as a "tool" rather than a "machine", so that it can encourage rather than restrict involvement. This means that the technology and materials composing the built environment should be transparent (i.e. comprehensible) in a way that encourages users' involvement, regardless of their technical skills and knowledge.

16.1.4 Conclusions

The argument in this chapter revolved around the possibility of introducing the ecological principle of interdependence to architectural environments. It has been argued that interdependencies between people and nature do exist, although they may be less obvious in urban areas than in natural settings. It has been suggested that one of architecture's 'purposes' may be to reveal and encourage interdependencies between people and natural processes. This may be achieved by shifting the focus of architecture from objects and forms into processes and tools. The conception of architecture as a tool for manifesting interdependencies between people and nature will be further explored in the next chapter by focusing on the idea of purposefulness in architecture.

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[24] See argument in section 11.1

16.2 Purposefulness in the context of the built environment

The significance of the principle of purposefulness in the part/whole relation within living systems is exemplified through the correlation in purpose[25] between the part (i.e. organism, plant) and the bigger ecosystem to which it belongs. Living systems purposeful or self-realisation tendency is 'inherited' from their environment, so that there is a correspondence in purpose between a living system and its context.

> The complexity of environment required for the emergence of self-realizing systems must itself in general be maintained in existence against the entropic inroads of the wider environment. In other words, selves in general require specialized environments in order to form, and these environments themselves constitute wider self-maintaining systems (Mathews, 1991: 143).

An environment which supports life, according to Mathews, is an environment which in itself forms part of a bigger living system, such that every system is embedded within a bigger system which supports its own self-realising qualities.
Within the context of the built environment, the idea of purposefulness can be exemplified through the correlation in purpose that exists between humans and the natural world. Therefore, it is suggested that a 'purposeful' architectural environment is an environment which supports correlation in purposes between people and their wider natural context. In this way, the already existing purposeful tendency of living systems is maintained and supported by human actions within the built environment. The following discussion will therefore examine the

[25] 'Purpose' in living systems refers to their capacity to self-realize their own existence (see discussion in section 5.2).

possible ways in which architecture may support 'purposeful' relations between people and nature.

16.2.1 Purposeful relations between people and nature

The discussion about purposefulness can begin by an inquiry into the importance of sustaining purposeful relations between people and nature.

It has been argued previously[26] that the correlation in purpose between organisms and their environment helps sustain and strengthen both the organisms and the environment which they support. In other words, by supporting the 'purpose' of their environment, organisms also support their own 'purpose' of existence and development, since the two are interdependent (Capra, 1982: 317). Following from the discussion about interdependence between humans and nature from the previous section, it can be assumed that humans' 'purpose' of self-realisation as living organisms can best be sustained by correlation with the 'purpose' of the natural environment from which they were created.

> The conatus[27] of the individual, by helping to shape the wider system, helps to sustain the conatus of that system, and the conatus of the system, by maintaining that specialized environment in existence, provides the conditions for the emergence of self-realizing forms. It is the dynamics of the conatus which is reflected up through the levels of the systems (Mathews, 1991: 155).

Supporting the conatus of natural living systems, or their inherent, dynamic developmental capacity, is therefore important not only for the sake of their own existence, but also for the sake of other living organisms' existence, including humans.

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[26] See section 5.2 about 'purposefulness.'

[27] 'Conatus' can be described as an inherent tendency for development (Mathews, 1991)

As a living organism, the human body learns about its environment through interaction with it. Through this interaction and correlation with its surrounding environment, the body slowly learns how to recognize and assimilate processes that it encounters in the environment in a way that makes sense to it and corresponds to its own mechanisms (Chiel & Beer, 1997). The human body experiences the world through its senses and perceptions, which are essentially dynamic mechanisms of operation (Thelen & Smith, 2003). For this reason, the body recognizes the world phenomena that it encounters as similarly live processes;

> To the sensing body *all* phenomena are animate, actively soliciting the participation of our senses, or else withdrawing from our focus and repelling our involvement. Things disclose themselves to our immediate perception as vectors, as styles of unfolding – not as finished chunks of matter given once and for all, but as dynamic ways of engaging the senses and modulating the body (Abram, 1996: 81).

The body's dynamic, live processes enable it to easily recognize other similar live and dynamic processes better than it may be able to recognize inert facts or data (Abram, 1996: 120). This may be exemplified by the fact that it is easier for us to remember details and facts when they are embedded within an unfolding story rather than presented as a collection of fragmented data without correlation between them.

It may similarly be the case that it is easier for the body to understand and assimilate facts about its surrounding environment, if this environment is experienced dynamically and not as a collection of isolated and independent objects. Being in direct contact with dynamic, natural processes may therefore be the best way for the human body to learn about nature, as part of a direct, correlated experience of the environment. Therefore, by corresponding people's everyday actions with natural processes, the purposefulness of both people and nature may be enhanced as a result.

16.2.2 Architecture as a tool for manifesting purposeful relations between people and nature

It may now be asked whether architecture can become a tool for manifesting purposeful relations between people and nature, and if so then how?

Christopher Alexander, in his book *A Pattern Language*, defines the built environment as a collection of patterns. According to Alexander, the ongoing interactions of people with their environments give rise to actual architectural patterns, which can be defined and built.

> In every age and every place the structure of our world is given to it, essentially, by some collection of patterns which keeps on repeating over and over again. These patters are not concrete elements, like bricks and doors - they are much deeper and more fluid - and yet they are the solid substance, underneath the surface, out of which a building or a town is always made (Alexander, 1979: 100).

Identifying the reoccurring patterns within a place is, therefore, a challenge that the architect or the planner is faced with, and these patterns can be given concrete shape and form.

Alexander's definition of the built environment as a collection of behavioural patterns is relevant to this argument because it begins to define a place in relation to the reoccurring dynamic contextual processes within the environment, rather than as an abstraction of an idea or function imposed on a place by the architect. But Alexander's interpretations of these contextual patterns in form remain static;

> A pattern represents both the comprehension of the problem and the comprehension of the set of physical relationships that are necessary to solve the problem (King, 1993: 22).

The drawback of using a language of patterns to design places is that they provide a 'recipe' for expressing behavioural patterns in form, i.e. they are *prescribed* solutions for architectural "problems." The problem with prescribed solutions is that they may be appropriate in some contexts but not in others, and also, that they are essentially fixed solutions. Fixed in the sense that once they are built it is very difficult to alter them or adjust them according to changing conditions.

The attempt to use architecture as a tool for creating purposeful relations between people and nature may require solutions that are more flexible than Alexander's architectural patterns. Solutions which can express the dynamic quality of natural processes in relation to the dynamic quality of human behaviour in the environment. For example, an architectural "problem" may be to design a path in an area full of trees. The action of walking can then be correlated with the growth cycles of the trees. An architectural pattern may be difficult to apply to express this dynamic 'purposeful' relation between the act of walking and the growth process of the trees, because patterns tend to provide 'static' solutions. A pattern in this case, may 'prescribe' that the path should include gaps in order to allow the roots of the tree to come through, or for the leaves of the tree to fall on the soil, etc[28]. An architectural pattern, therefore, provides a prescription for "how such a path should be designed." An architectural system, on the other hand, may allow more flexibility in interpretation, as long as the growth cycle of the tree and the action of walking support one another.

[28] See for example pattern no. 51 "green streets" in Alexander's *A pattern language* (1977)

Habraken explains why systems provide more flexible architectural solutions than patterns;

> The pattern is a recipe intended to produce a certain outcome. Systems, on the other hand, allow far greater freedom to make any configuration desired: what matters most is the relation of parts, not the particular configurations. In a building construction system, for instance, we may know exactly how the ends of wooden floor beams must be fire cut, then laid into the grouted mansory beam pocket. But there is no inherent specification as to length or number of walls or floors. We are free to make any configuration as long as we observe the relational constraints. In a pattern this would not do: the configuration itself, with due allowance for variations in dimension and in some aspects of selection, would be largely predetermined (Habraken, 2000: 249).

In the case of the walking path amongst trees, an architectural system, as opposed to a pattern, may describe the possible relationships between the act of walking and the growth cycle of the trees depending on the different months of the year, in a specific context, without specifying what "should be done." For example, in autumn, when the leaves fall on the ground, the relation between the use of the path and the falling leaves should allow for the leaves to return to the soil. In winter, when the ground is wet and muddy, the path should still enable walking on it, without blocking the absorption of the rain in the ground, so a raised pathway with gaps in it may be an appropriate solution in this case (but other solutions that satisfy both conditions are also plausible). This means that the design of the path should take into account all the possible relationships between the trees and soil "needs" and people's "needs" at different times of the year and enable both to occur at the same time, and possibly to enhance one another.

It may even be the case that an architectural solution can be found which is flexible enough and can be transfigured to suit changing seasonal conditions. People's needs, when they walk through an outdoor path, may change according to the seasons, in the same way that the trees' growth cycle change. So, people's needs and trees' growth cycles can be designed to compliment one another. For example, a raised pathway may be good during the rainy months, and in the dry season it can be assembled to provide sitting places underneath the trees. This kind of adaptive architectural system can be designed differently, depending on context and climatic conditions, and the natural/behavioural processes that it intends to support.

16.2.3 Conclusions

The argument in this chapter aimed to introduce the idea of purposefulness into architectural environments. Purposefulness here refers to the correlation in purpose between behavioural processes and natural processes, and the possibilities of expressing these correlations through the design of the built environment. It has been suggested that the 'purpose' of natural living systems corresponds to the 'purpose' of the human body, which is mainly that of survival and development. By supporting living processes in nature, humans are able to strengthen their own internal living processes, since all living processes are interdependent. It may therefore be appropriate to design our built environments in ways which support correlation in purposes between people and nature. This may be achieved by aiming to design architectural systems that integrate contextual natural processes with functional behavioural processes.

16.3 Autopoiesis in the context of the built environment

The significance of the principle of autopoiesis in the part/whole relation within living systems is in stressing the continuous self-generating capacity of living systems to recreate their own internal processes, through the interactions of their composing components. In other words, through the interaction of the parts - the whole is maintained.
Within the context of the built environment, the idea of autopoiesis can become manifested through the interrelations of its composing living parts, i.e. people and natural processes. Through their interactions with one another, and with natural processes, users of the built environment can help (re)generate and (re)create the living environment of which they are a part by constantly engaging with it. The following argument will aim to explore how architecture may support and enable an autopoietic process between its users and nature.

16.3.1 The significance of autopiesis in the environment

The discussion will begin by exploring the need to maintain autopoiesis in the environment in the first place. Autopoieis is a property of living systems which defines their very essence;

> It is the circularity of its organization that makes a living system a unit of interactions, and it is this circularity that it must maintain in order to remain a living system and to retain its identity through different interactions (Maturana, 1970: 9).

According to Maturana, it is the autopoietic quality of a living system which enables it to retain its 'identity' as it interacts with various processes. Moreover, as a living system interacts with its environment, these interactions must support its autopoiesis, otherwise the system may die.

> Living systems are molecular autopoietic systems. As molecular systems living systems are open to the flow of matter and energy. As autopoietic systems living systems are systems closed in their dynamics of states in the sense that they are alive only while all their structural changes are structural changes that conserve their autopoiesis. That is, a living system dies when its autopoiesis stops being conserved through its structural changes (Maturana, 1997: 1).

The above quotation stresses the significance of autpoiesis to the existence of living systems, without excluding the possibility that interactions with the environment can support autopoiesis of a living system, as long as the outcomes of these interactions are manifested as internal "structural changes" which conserve the system's autopoiesis. Maturana defines "structural change" as an outcome of a reciprocal process between a living system and its environment;

> The medium as the space in which a system operates as a whole, has a structural dynamics independent of the structural dynamics of the systems that it contains, although it is modulated through its encounters with them. So, the medium and the system that it contains are in continuous structural changes, each according to its own structural dynamics, and each modulated by the structural changes that they trigger on each other through their recursive encounters. In these circumstances all systems that interact with a living system constitute its medium. Furthermore, according to the recursive dynamics of reciprocal interactions described above, all systems in recursive interactions change together congruently (Maturana, 1997: 3).

Bringing the discussion back to architecture, it can be assumed that the existence of a built structure in the environment influences the autopoiesis of living systems in its vicinity, since the built structure functions as a medium with which these living systems interact. Instead of encouraging interactions between people and nature, which can support the autopoiesis (i.e. self-creation) of both, architecture, in most cases, tends to separate people from natural processes and, therefore, blocks possibilities for exchanges between them.

Acknowledging the influence of the built environment on the autopoiesis of both people and nature may be a first step in attempting to integrate architecture with autopoietic cycles instead of interfering with them. The possibilities for achieving this will be explored in the next paragraph.

16.3.2 Architecture as a tool for enhancing autopoiesis in the environment

The environment in which a living system operates influences the system's autopoiesis through internal structural changes, as has been explained in the previous paragraph. This is a process of adaptation which affects both the system and its environment. Through years of evolution, humans have adapted to the natural environment surrounding them, and as a result, developed an autopoietic mechanism which is suited to natural processes in the environment (Goldsmith, 1998: 298). Human perceptive faculties are therefore suited to providing us with the subjective knowledge of our relationship with our environment that we require for adaptive purposes, but only "so long as its basic features have not been allowed to diverge too much from those which we have been adapted to by our evolution and upbringing. As our environment moves beyond these limits, however, our perceptions become ever less useful for understanding it and for helping us to adapt to it; we cease, in fact, to be cognitively adjusted to it" (Goldsmith, 1998:

298). As Goldsmith points out, there is a danger for humans in living within environments that do not resemble the environments in which we evolved (i.e. natural ones), because this means that we do not know how to "read" them, understand them and adapt to them. It can therefore be assumed, that by surrounding ourselves with built environments that do not enable us to come into close contact with nature, we, in fact, cause disruption to our own internal cognitive, autopoietic mechanisms. The result is that humans feel alienated from their environments since we are no longer able to understand and internalise them (Martin, 1993: 43).

The way in which we, as humans, perceive and understand our environments is therefore important for our internal autopoietic processes and for our ability to feel part of our surrounding environment. This also influences our ability to engage with and take part in the formation of the environment, since a lack of understanding leads to alienation (Thayer, 1994: 141).

So how can design contribute to our understanding of the environment?

An initial distinction between panoramic and participatory landscapes may provide some helpful clues. A panoramic landscape is a type of landscape which emphasizes physical distance and breadth of scope. It is a primarily visual experience that carries a sense of separation between viewer and landscape. On the other hand, the participatory landscape is a type of landscape which develops a spatial continuity with a person. The space reaches out to encompass the viewer as a participant. One does not contemplate such a landscape; one enters it (Nasar, 1998: 87-96). The participatory landscape differs from the panoramic landscape in the way it engages the user with it – it appeals to the user's perceptual experience and tries to draw in the various senses into participation with it. Movement and time are also essential components of such an experience: "what is important are not physical traits but perceptual ones, not how things are but how

they are experienced" (Nasar, 1998: 96). The distinction that Nasar makes between the two different types of landscapes can be applied to the way people relate to buildings or other designed systems.
A panoramic building or system can be described as a system which invites observation; it may therefore generate a certain level of distance between viewer and object, and it does not invite engagement or participation with it. A participatory building or system, on the other hand, can be described as one that invites participation by making us want to interact with it, and therefore, may generate a high level of engagement and comprehension.
An environment which offers us possibilities to engage with it, also offers us the possibility to alter our internal autopoietic processes, as living beings, through these possible interactions. On the other hand, an environment which blocks such possibilities for interactions with our surroundings, does not offer us any options for development, as living beings, by challenging our internal autopoietic processes.
It may therefore be assumed, that designing built environments which invite participation is important for people's development as living beings. The notion of participatory landscapes is therefore important for people's autopoiesis. But how can the design of the built environment enhance the autopoiesis of other living systems, which are not human?
One approach is to view nature as a collection of living, autopoietic processes, and the building as a non-living system, which should aim to minimize its interference with living processes. This approach is exemplified by many sustainable architectural solutions, which aim to reduce harmful impacts on natural processes by minimizing the inputs and outputs of the building[29]. A different approach may be to view the built environment as a medium through which two autopoietic systems interact (one is humans and the other is

[29] See discussion in section 10.2

nature), such that each is modulated by the structural changes that it triggers on the other through their recursive encounters. This approach entails that the structure of the built environment should be such that it encourages as many interactions between people and natural processes as possible, and that through these interactions people learn what kind of 'actions' are desirable for enhancing overall autopoiesis in the environment (this includes their own autopoiesis as well as that of nature). Therefore, instead of imposing strict rules and regulations for 'sustainable' buildings, this type of approach enlarges the scope of sustainability by promoting experimentation in the type of relationships that will enhance autopoiesis of both humans and nature.

It has already been argued that participatory environments can potentially enhance people's autopoiesis. This observation can now be enlarged to include natural processes in the design for participation. In other words, the architectural environment should not only encourage any type of participation, but specifically participation with natural processes, so that the autopoiesis of nature can be enhanced as well. In this way architecture can become a medium for enhancing overall autopoiesis in the environment by encouraging interactions between people and nature.

16.3.3 Conclusions

The discussion in this chapter aimed to introduce the idea of autopoiesis into built environments. It has been observed that a living system's autopoiesis is maintained by the interactions of its parts. A living system tends to undergo 'structural changes' through adaptation to its environment. The built environment can therefore be assumed to influence all living systems that come into contact with it (this may include people as well as other living processes). It has been suggested that the built environment, rather than interfering with autopoiesis of living systems, can perhaps become a medium for enhancing it. This may be achieved by designing built environments that encourage interactions and participation of people with natural processes in the environment. In this way, people, through their engagement with natural processes, can become 'parts' in the overall autopoiesis of nature.

16.4 General Conclusion – Part /Whole

The distinction between the part and the whole within the context of the built environment has been defined as the distinction between people (representing the 'parts') and the natural environment (representing the 'whole'). Architecture is then viewed as a tool for manifesting the relations between the parts and the whole, or between people and nature. The relationship between people and nature has been explored according to three ecological principles that illuminate the part/whole relation within living systems.

1. *Interdependence* - the first principle describes interdependencies between people and nature. It has been suggested that architecture can be used as a tool to reflect the existing interdependencies between people and natural processes on site.
2. *Purposefulness* – the second principle describes the correlation in purposes between people and nature. It has been suggested that architecture, used as a tool to reflect interdependencies between people and nature, can be adapted to accommodate correlations between behavioural processes and natural processes. In this way, the purpose of the body, which is to remain active and engaged with its environment, can integrate with existing natural processes on site.
3. *Autopoiesis* – the third principle describes the process of autopoiesis, or self-creation, in living systems, which includes both people and natural processes. It has been suggested that architecture can become a tool for achieving overall autopoiesis in the environment by providing as many interactive opportunities as possible between people and nature. In this way, people, through their engagement with

natural processes, can become 'parts' in the overall autopoiesis of nature.

The next chapter will examine the nature of the relational dynamics between people and natural processes as part of the built environment.

17. The principle of Relational Dynamics

The principle of relational dynamics described the constant dynamic relations between the different parts in a living system, and between the parts and the whole system. In the context of architecture, the relations between the parts refer to the dynamic relations between the different types of users of the built environment, and the relation to the whole describes their different possible dynamic relations to natural processes.

The following chapter will examine the different possible relational dynamics between people and natural processes through three main ecological principles: (1)Positional value, (2)Feedback mechanism, and (3)Homeostasis. Each one of them will be explored in turn in regards to its possible applications within the context of the built environment.

17.1 Positional Value in the context of the built environment

The significance of the principle of positional value in the relational dynamics within a living system is in stressing how the relative position of an agent within the system influences its significance to the system as a whole through its interactions with other agents. In other words, the position of an agent within the system influences its ability to interact with other agents, and through that, it determines its relative influence on the system as a whole, since the system is maintained by its agents' interactions (i.e 'autopoiesis'). The notion of 'positional value' within the context of the built environment can refer to the 'position' of users within the environment, and how this position determines and influences their interactions with natural processes. It can also refer to the 'position' of architecture, as a tool for enhancing people-nature relations, within its wider context, and how its relative position can influence the way in which users interact with natural processes. The following argument will examine how people's positional value in the environment and how architecture's positional value in the environment may be assessed.

17.1.1 People's positional value in the context of the built environment

People's position within the environment can be determined and assessed in relation to many aspects apparent in the environment. It can be determined in relation to other people, in relation to specific focal points in the environment (i.e. city centre, main travel routes, etc.), or any other points which are determined in advance. Since this thesis focuses on the relations between people and nature, and the way in which architecture facilitates these relations, people's positional values in the environment will be determined in relation to natural processes. This means that a "high positional value" will refer to a high potential for involvement with natural processes in the environment, while a "low positional value" will refer to a low potential for involvement with natural processes. The implications of these definitions will be assessed in what follows. First, it must be clarified what is intended by the use of the word "involvement." Involvement with the environment is considered to be significant for the process of environmental appropriation. Environmental appropriation is described by Dovey as a process by which people become identified with the environment through engagement and concern.

> Appropriation is closely related to the process of identification. As we open ourselves to the world of things and places, we bring them meaning through our care and concern, and at the same time these things and places lend meaning to our sense of identity. Appropriation is rooted, therefore, in a concerned action through which we appropriate aspects of our world as anchors for our self-identity (Dovey, 1985: 37-8).

Environmental appropriation is therefore associated with a process of active concern for things and places, and it is a process which enables us to feel part of the environment which surrounds us. This links to the notion of the 'participatory landscape' from the previous chapter, which described places that "draw us in" and make us become part of them. The idea of "involvement" then, may be described as a way of becoming part of the environment by appropriating it, that is, by caring for it and engaging with it in an active way, such that it becomes part of our experience and we are able to identify with it.

In relation to natural processes in the environment, the process of appropriation may become significant in re-connecting people to nature through everyday actions in their environment, which integrate with natural processes. In this sense, the positional value of people in the environment can be defined in relation the potential degree of involvement that they may have with natural processes in that environment. This potential is defined not only by the design itself, which can create opportunities for engagements with natural processes, but also by the *frequency* and *type* of involvement that people have with the environment in different places. For example, a public place such as a train station may afford many possibilities for engagement with natural processes, but the fleeting nature of these engagements, in such a place, may counteract the potential for people to appropriate the environment. On the other hand, similar affordances for involvement with natural processes in a dwelling unit may generate more meaningful and lasting processes of appropriation, since people's involvements with the place are permanent or long-term, rather than fleeting.

It can therefore be assumed that positional values of users in the context of the built environment are dependent upon *frequency* of use (how often do they interact with the place) and *type* of use (how do they actually interact with the place, how long do they stay there, and for what reasons). One example may be a residential street, in which there are different types of users, such as: residents, visitors, maintenance people, people passing-through, etc. Each one of these users will have a different positional value in the street, which is dependent on the frequency and type of use. Assessing their positional values can help architects to design different types of involvements for these users with natural processes in order to promote appropriation of the environment (on different levels).

The following table illustrates, as an example, the different positional values of the different possible users of a residential street, according to the frequency and type of use.

User	Positional value (frequency)	Positional value (type)
Resident	High (daily)	High (significant)
Visitor	Low (occasional)	Medium (some significance)
Maintenance person	Medium (weekly/monthly)	Medium (some significance)
Passer-by	Ranging (from daily to rarely)	Low (not significant)

Table no.7 – Mapping positional values of possible users in a residential street.

The above table illustrates how different positional values of users can be determined in the environment. These positional values can inform designers regarding the level of involvement that can be expected from a certain type of user in relation to natural processes. For example, in the context of the residential street, it can be expected that residents will have the highest level of involvement with natural processes, while passers-by and visitors will have the lowest level of involvement. Therefore, the possibilities for designing interdependencies between residents' behavioural processes and natural processes, in this context, provide the highest potential for involvement; while the possibilities for designing interdependencies between passers-by and visitors' behavioural processes and nature provide the lowest potential for involvement in this case.
Involvement with the environment is significant both on an individual as well as on a collective level. People feel "at home" through engaging with the environment and those individual acts of appropriation have consequences on the larger environmental scale. Habraken describes the relation between an architectural "type," which is an expression of a certain act in built form, and collective appropriation. The two reinforce one another and by that slowly form a built environment on a scale of a city.

> Environmental types exist to be made, then appropriated. The daily rhythm of ongoing inhabitation links them to social bodies, shaping our movements, habits, and social relations. The experiential relationship between type and inhabitation transcends function. It is existential, encompassing all that surrounds us. The act of inhabitation reaffirms type through daily interaction, just as such continuity and repetition over time initially create the type (Habraken, 2000: 279).

The action of inhabiting a place leads to its appropriation and this appropriation reaffirms the architectural type as a social construction. The importance of this process is in creating a sense of belonging through continuous engagement between people and their environment, and a constant re-creation of that environment to suit changing needs. By distinguishing between the different types of users that 'inhabit' an environment, the process of involvement with the environment, and with the natural processes that compose it, can become apparent, and as a result - responsibility for the environment and nature can be promoted.

Designing for differentiating levels of involvement between people and natural processes can promote different levels of responsibility for the environment and natural processes that compose it. By making these different levels of responsibility apparent, users can learn not only about natural processes per se, but also about their own level of responsibility for maintaining and participating in these processes. So, by being able to experience how the environment is affected by their own actions, people can re-establish their sense of belonging and responsibility for their environments. But what is the actual role of the architectural elements themselves in establishing different types of relational dynamics between people and natural processes? This question will be examined in the following paragraph.

17.1.2 Architecture's positional value in the context of nature

Architecture's position within its context can be determined and assessed in relation to different aspects which are apparent in the environment. It can be determined as a relation of one building or unit in relation to others, or in relation to the way in which people engage with it, or in relation to its effects on natural processes, etc. Since this thesis focuses on the relations between people and nature, and the way in which architecture facilitates these relations, architecture's positional value in the environment will be determined according to the type of relation that it facilitates between people and natural processes. A "high positional value" will refer to an architectural system which provides a high potential for involvement with natural processes in the environment, while a "low positional value" will refer to an architectural system which provides a low potential for involvement with natural processes. The implications of these definitions will be assessed in relation to the following discussion.

Ihde (quoted in Verbeek, 2005) describes three different types of relations between people and technology, and the influence these relations have on the way people experience the world. His distinctions are useful in determining the different types of relations that architecture can facilitate between people and nature.

1. The first type of relations between people and technology that Ihde describes is that of '*mediated perceptions,*' according to which our relation to the world is mediated by artefacts. He divides mediated perceptions into two kinds: (a)embodiment relations, and (b)hermeneutic relations. In embodiment relations, humans take technological artefacts into their experiencing, and thereby broaden the area of sensitivity of their bodies to the world. An example is the wearing of eyeglasses; "When I wear eyeglasses, I do not look *at* them but *through* them at the world. I take the pair of glasses into myself; it withdraws from my perceiving" (Verbeek on Ihde, 2005:

125). With embodiment relations, humans focus on the work in which they are engaged and not on the tool itself. Applied to architectural systems, the idea of embodiment relations can refer to an architectural system which compliments existing natural processes, in a way that enables people to experience them better. An example may be a system of transparent water pipes, so that people are able to see and experience the water cycles in their environment.

In hermeneutic relations, according to Ihde, humans are still involved with the world *via* an artefact, but this time the artefact is not transparent. An example is the use of a thermometer; "when we read a thermometer, we are not involved with the thermometer but with the world, of which the thermometer reveals one aspect, namely, its temperature. This revealing, however, does not have the character of a sensing of temperature but is rather a *representation* of it" (Verbeek, 2005: 126). Another example may be a technological gauge which reveals to us the level of air pollutants in our garden.

2. The second type of relations that Ihde describes is '*alterity relations.*' In alterity relations humans are related directly to technology rather than, as with mediating relations, related to the world *via* technology. In this type of relations technology possesses a kind of independence and gives rise to an interaction of people with it. An example is automatic train ticket machines, which "not only take money and dispense tickets, but also give advice, provide route information, answer questions, and protest when something is done incorrectly" (Verbeek on Ihde, 2005: 127). An architectural example may be a computerised system, embedded within the built environment, which tells us a generic story about natural processes without directly engaging us with a specific context. This involvement with a computer game therefore replaces a direct engagement with live, contextual processes in the environment.

3. The third and final type of human-technology relations that Ihde identifies is that of *background relations*. In background relations technologies are present and absent at the same time. They create a background field which gives form to human experience by shaping a context for it, without us noticing them. Refrigerators and central heating systems are examples (Verbeek, 2005: 128). Within the built environment, background relations are apparent all around us, in the form of various infrastructures and services systems that compose our environments. Roads, sidewalks, and rail tracks are examples of background transportation infrastructures, which determine the character of our landscapes and urban environments, and which, because we are so used to, we may no longer notice. Other background relations arise from various services providers, such as sewage systems, electricity and communication networks, etc. The proliferation of background relations within the built environment can become a possibility, rather than an impediment for enhancing people-nature relations. Background relations, because of their half-hidden nature, carry the potential for *revealing* instead of hiding the networks and layers of relations that exist in the environment. Instead of aiming to hide electricity and communication cables, they can be designed to reveal how energy is transferred from one place to another and how audio or colour waves travel in space. The more complicated the background relations may be, the more possibilities they may encapsulate for transferring information about the natural processes that they embody. People have the right to know how their environment functions, and it is the designer's responsibility to reveal the nature of the relationships between the various processes that compose the environment, no matter how complex they may be. Ecologists, technologists, and other experts responsible for the structure and function of various technological and environmental networks in our environments, should collaborate with designers in aiming to make

the structure of various 'background' relations become the foreground of our lives, since they have come to pervade such a large percentage of our daily environments.

Ihde's distinctions between the different types of relations that technology mediates between people and the environment is highly relevant for architecture and the different types of relations that it enables between people and natural processes.
It can be summarised, that an architectural system, which promotes alterity relations, is one with a low positional value, since it offers a low potential for involvement between people and natural processes (i.e. it replaces our engagement with nature for an engagement with a technology). An architectural system which promotes mediated relations is one with a high positional value, since it offers a high potential for engagement between people and natural processes (i.e. it enhances our experience of natural processes in the environment). An architectural system which promotes background relations has the potential to have either very low or very high positional value, depending on the degree to which these relations can be transformed from background (i.e. unnoticed) to foreground (i.e. revealing its network of relations to us, with all their complexity).

17.1.3 Conclusions

The discussion in this chapter aimed to introduce the concept of positional value into the built environment, by differentiating between people's positional values and architecture's positional values. It has been observed that users can posses different positional values within a given context, depending on their frequency and type of involvement with that context, and that their relation to natural processes can be designed in accordance with their positional value. It has also been observed that architecture can possess different positional values within a given context, according to the type of relation that it facilitates between people and natural processes in that environment. It has been concluded that architecture possessed the highest positional value, in that respect, when it facilitates *mediated relations* or background-*foreground* relations between people and nature.

17.2 Feedback Mechanisms in the context of the built environment

The principle of feedback is highly significant for the relational dynamics within living systems, since feedback provides the actual steering mechanism within a system. Feedback, therefore, is a form of communication between agents within a living system. Since all living systems are part of an overall living mechanism, which is sometimes referred to as the system of Gaia, they all participate in one regulative feedback mechanism, which is composed of smaller feedback mechanisms within local ecosystems (Lovelock, 1979). There are two main types of feedback relations in living systems: one is negative feedback, which counteracts disturbances, and helps to keep the system in a state of equilibrium; and the second is positive feedback, which drives the system away from equilibrium and allows it either to evolve into a new state or degrade into chaos[30].

Within the context of the built environment, feedback mechanisms can be applied as a form of "communication" between people and natural processes. The role of architecture can therefore be viewed as the "communication tool" with which feedback between people and nature is regulated. The way in which feedback relations between people and nature may be supported through the built environment will be explored in the following discussion.

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[30] See discussion on feedback in section 6.2

17.2.1 The role of the user in introducing feedback relations into the built environment

Introducing feedback relations between people and nature as part of the built environment is dependent upon the user's involvement with architecture as much (or arguably even more) as it is dependent on the technology employed as part of the architectural design. As Carlo observed in the 1970's;

> An architectural work has no sense if dissociated from use, and the way in which it is used, or can be used, is one of the fundamental factors contributing to the definition of its quality. As an empty vessel, it cannot represent itself or establish purposeful relations with nature and history; because its purpose lies in its 'fullness' - in the whole set of relationships established with those for whom it was designed (Carlo, 1970: 29).

It is therefore important to initially establish who will use and activate the feedback mechanisms in the built environment, in a specific context, and at what frequency, so that the feedback mechanism can be compatible not only with the natural process(es) that it supports, but also with the probable user(s) that will be activating it. After all, feedback is a two-way steering system, which should be adaptable to both sides.

Since the overarching aim of applying the ecological principles to architecture is to connect people to natural processes, then the most compatible medium for achieving this type of connection, through feedback, may be a tool which allows people to connect to natural processes on as many levels as possible; experiential as well as logical (i.e. being able to understand what is perceived). It could preferably be a tool that engages as many of our senses as possible. As Abram explains: "it is only at the scale of our direct, *sensory* interactions with the land around us that we can appropriately notice and respond to the immediate needs of the living world" (Abram, 1996: 268, *my Itallics*).

The level of engagement that people may have with natural processes, through the built environment, is also dependent upon the way in which they use the place and the frequency of use. As people become identified with places through their level of care and concern for them (Dovey, 1985), it may be assumed that the probability of truly engaging with natural processes may be higher at places where people spend most of their time, and grow to care for, rather than at random places of transit. Therefore, applying the notion of 'positional value' to users may be useful in determining the type of feedback mechanism that is appropriate at a certain place, in relation to the various users that come into contact with it.
Borrowing the example of a residential street from the previous chapter, we may assume the following differentiated levels of feedback relations among the various users, corresponding to probable levels of engagement with natural processes on this specific site.

Users' positional values	**Probable engagement with natural processes on site**	**Probability for feedback relations**
Resident (high)	Frequent and direct	High and varied
Visitor (low)	Occasional	Low
Maintenance person (medium)	Frequent and partial	Specific
Passer-by (low)	Fleeting	Low

Table no.8 – Mapping users' role in introducing feedback relations in a residential street.

It can be observed from the above table that the perceived positional values of specific users, in this context, correspond to the probability of their feedback relations with natural processes.
It may therefore be assumed, that in this specific example it makes more sense to concentrate on designing feedback relations between

residents and natural processes, since they present the highest probability for engaging with natural processes in this context. Another example may provide a different view:

Users' positional values	**Probable engagement with natural processes on site**	**Probability for feedback relations**
Passengers (high)	Frequent and fleeting	High and ranging
Employees (high)	Frequent and direct	High and specific

Table no.9 - Mapping users' role in introducing feedback relations at a train station.

The above table illustrates the positional values and probable feedback relations between different types of users and natural processes in a train station. It can be observed that both types of users (passengers and employees) present high probability for engagement with natural processes, although in a slightly different manner. While employees can be expected to have more 'permanent' relation with the place, since they may spend all day there, passengers, on the other hand, can be expected to have more fleeting and changing relationship to the place. Still, both types of users provide a high probability for engagement with natural processes, in this context, although their way of engaging with them will probably be different, and therefore different types of feedback mechanisms may be appropriate in this case.
It can be summarised, that by mapping the positional values of different types of users in a specific context, the probably of their engagement with natural processes can be revealed, which can inform the design process of different possible feedback mechanisms suited to that context. The next paragraph will focus on the different possible ways of relating to natural processes within the context of the built environment.

17.2.2. The role of architecture in introducing feedback relations into the built environment

The discussion in the previous chapter has revealed that there are different possible 'positional values' for architecture in the context of the built environment. This entails that architecture can facilitate different types of relations between people and natural processes, and these were distinguished according to Ihde's model. Ihde described three types of relations that technology facilitates between people and the world, and these were: mediated, alterity and background relations (Ihde, quoted in Verbeek, 2005: 125-8). The following table illustrates how these different types of relations can inform the design of feedback relations between people and natural processes in the built environment;

Architecture's positional value	Relation to natural processes	Options for feedback relations
Mediated - Hermeneutics	Representational understanding	May lead to /anticipate intervention
Mediated - embodiment	Direct, personal experience	Ongoing, small interventions
Alterity	Generic understanding	Not necessarily lead to direct intervention
Background	Continuous experience (of a process) which is likely to be shared	Possibility for collective intervention

Table no.10 – Mapping architecture's role in introducing feedback relations.

The above table explains the different possible 'roles' of each type of relationship (represented by the different architectural 'positional values') in leading to a possible feedback relation between people and nature. While alterity relations may provide a more generic understanding of natural processes, mediated-embodiment relations provide an actual "hands-on" relationship between people and nature, while background relations are more likely to represent shared infrastructures and can therefore lead to collective interventions (of more than one user). Acknowledging the different possible types of relations that architecture can enable people to have with nature is a first step in opening ecological relations between people and nature through the built environment. Differentiating between various possible types of natural processes that are apparent in the environment, and may impact planning and design considerations, may be a second step in trying to relate the different 'positional values' of architecture to actual natural processes. These possible differentiations are illustrated in the following table. The six different types of natural processes described in the table below (Soil, air/wind, sun/energy, water, flora, and fauna) are based on common types of natural processes as explained in McHarg (1997: 117).

Natural process	**Architecture' positional value**			
	Mediated - hermeneutics	*Mediated - embodiment*	*Alterity*	*Background*
Soil	Reveal soil conditions	Provide possibilities for utilising and enriching the soil	Learn about types of soil	Reveal interrelated, contextual soil processes
Wind / Air	Reveal air/wind conditions	Provide possibilities for cleaning air/ utilising wind	Learn about wind currents / air pollutants	Reveal interrelated, contextual air /wind processes
Sun / energy	Reveal sun conditions/ energy levels	Provide possibilities for utilising sun/energy	Learn about sun/energy processes	Reveal interrelated, contextual sun/energy levels
Water	Reveal water conditions	Provide possibilities for utilising and purifying water	Learn about water cycles	Reveal interrelated, contextual water cycles
Flora	Reveal flora conditions	Provide possibilities for enhancing flora	Learn about types of flora	Reveal interrelated, contextual flora
Fauna	Reveal fauna conditions	Provide possibilities for enhancing fauna	Learn about types of fauna	Reveal interrelated, contextual fauna

Table no.11 – Mapping architecture's role in introducing feedback in relation to different natural processes.

The above table describes how each one of the various architectural 'positional values' can inform a different aspect in relating to different natural processes (earth, wind/air, fire/light, water, flora and fauna). The suggested positional values therefore prove useful in establishing different feedback relations between people and nature, through the built environment.

17.2.3 Conclusions

The discussion in this chapter aimed to introduce the idea of feedback relations into the built environment. It has been suggested that feedback relations between people and natural processes can be introduced into the built environment by differentiating between different types of users and their various levels of engagement with a place, in order to be able to design feedback mechanisms that are suitable for various users within a specific context. Arguably, this would make the feedback relations more likely to occur. Feedback relations can also be differentiated by the various 'positional values' of architecture in relation to natural processes (see table no.11). This may help in differentiating between various 'roles' that each feedback mechanism can play in relating people with natural processes (i.e. mediate, alterity or background relations).

The discussion in the following chapter will focus on the possibilities for achieving overall homeostasis by utilising the different feedback relations.

17.3 Homeostasis in the context of the built environment

The significance of the principle of homeostasis to the relational dynamics within living systems is in ensuring that all of the activity and adaptability that occurs within living systems is directed towards the maintenance of a certain state of equilibrium, which is also referred to as homeostasis[31]. It is mostly through negative feedback, which counteracts disturbances, that a living system is able to maintain its homeostasis.

> Negative feedback, then, is a way of reaching an equilibrium point despite unpredictable - and changing - external conditions. The "negativity" keeps the system in check, just as "positive feedback" propels other systems onward (Johnson, 2001: 138).

The following discussion will explore the possibilities for maintaining homeostasis between people and natural processes within the context of the built environment, by investigating possible applications of negative feedback in that context.

17.3.1 Encouraging negative feedback between people and nature through the built environment

Johnson defines the purpose of negative feedback in complex systems as follows;

> At its most schematic, negative feedback entails comparing the current state of a system to the desired state, and pushing the system in a direction that minimizes the difference between the two states (Johnson, 2001: 140).

[31] See discussion in section 6.3 about homeostasis.

In the context of nature, most living systems' "desired state" can be considered to be a state of homeostasis (Goldsmith, 1998: 137). Homeostasis is therefore manifested as a climax condition in most living systems, including humans. The human body's inherent capacity to regulate its own internal processes and adapt to changing environmental conditions is part of the body's tendency for homeostasis. The body's constant activity is a manifestation of its adaptation to ongoing changing internal and external conditions, which allows it to maintain more-or-less constant conditions for its continued survival and development. Maintaining regular contact with natural processes in the environment, or in other words, with the larger living system of which it is a part, is one of the body's basic requirements for wellbeing, just as any other living system's development may entail. Therefore, a built environment which is integrated with natural processes and reveals their pace and cycles of activity is a healthier and more nourishing environment for the human body to be a part of than an environment which is cut off from such processes (Ulrich, 1993: 100). It may be assumed that by participating in the maintenance of natural processes in their environments, humans can become better connected to the natural world, which, in turn, contributes to their own wellbeing.

By linking different architectural features with natural processes, people can become part of the natural processes in their environments through the operation of the built system in relation to these natural processes.

One example may be an architectural feature that aims to link people with water cycles by exposing the water pipes within a building, instead of hiding them inside walls and underneath floors. Seeing the path that the water makes inside a building is a first step in attempting to generate feedback relations between people and water cycles. At this stage there are still no apparent feedback relations between the building occupants and the water cycle, except a possibility for the occupants to become aware of the water's path. A second step may be to design transparent water pipes, so that occupants can begin to notice the quality of the water as it travels through the building, and points along the path where the water may become polluted. At this stage feedback between the occupants and the water may become possible as occupants begin to notice how some of their actions within the building influence the quality of the water. For example, it can become apparent that one simple act such as washing dishes causes the water to become contaminated with various food remains as well as chemicals from the soap. The transparency of the consequences of certain actions performed daily within the building on natural processes (in this case - water), can enhance the possibility for feedback between people's behaviour and natural processes, mediated by the design of the built system. Therefore, by exposing the direct relationship between actions and their consequences, negative (i.e. balancing or counteracting) feedback relations become possible, and natural processes' homeostasis can be restored, to a certain extent, by changing certain behavioural patterns. In the case of the water cycle, transparency may be enough to encourage negative feedback, i.e. a change in behaviour that can restore homeostasis, but in other cases, more complex design interventions may be required. For example, restoring homeostasis to the soil through design that encourages a change in behaviour may require an integration of several architectural features that combine a way of revealing soil conditions in relation to certain user behaviours. The complexity of the regulation process between various human activities and different natural processes in the built environment, which may lead to homeostasis, will be explored next.

17.3.2 Integrating different use patterns with natural processes to encourage homeostasis

Aspiring to homeostasis in an environment which includes many different types of users is a complex task. One person's balancing actions can easily be confiscated by many others cumulative destructive effects. It is therefore essential to consider possibilities for developing an overall balancing mechanism that is based on the coordination of various simultaneous actions.
Living systems and various other complex adaptive systems usually possess a self-balancing or self-regulation capacity, which enables them to maintain an overall homeostasis. But how can the built environment develop such a self-balancing capacity in relation to natural processes, which takes into account all its various users and the consequences of their collective behaviours?

Habraken (2000: 11) defines three different types of orders in the built environment:

1. The first is physical order (form)
2. The second is territorial order (space)
3. The third is social order, or Understanding (consensus among agents).

The interrelations among the three orders define the structure of the built environment, according to Habraken. The differentiation between the three orders is helpful in mitigating the influences of each level on the formation of the overall built environment that people inhabit. While the first order refers to the physical matter that composes the built environment, the second order brings into play various territorial negotiations, which include the control of space by people as well as other living creatures (Habraken, 2000: 11). It is at this level that the constant use of feedback relations between people's actions and natural processes can promote environmental homeostasis. The third level is the level of social consensus, and it is at this level that negotiations about the relative significance of natural processes, within the built environment, can be adopted or rejected as part of a cultural environmental negotiation process.

The environmental negotiation process begins with a single agent's occupation of space, which forms a 'live configuration' that is under one agent's control.

> Configurations actively under unified control of a single agent – we will call live configurations. Any grouping of parts entirely under control of a single agent, such that their distribution in space has been determined or accepted by that agent and can be changed by that agent, constitutes a live configuration. Thus defined, a live configuration "behaves" like a single self-organizing entity (Habraken, 2000: 18).

In relation to the introduction of natural processes into the built environment, it becomes clear that a feedback-relations process which is under the control of a single user, can become part of a 'live configuration' in the environment of that specific user and in that sense, "behave" like a self-organising system. It is when more than one user become involved in a configuration that the environmental game becomes more complex;

> Agents in control must communicate, negotiate, bargain, and cooperate. Such direct interactions are necessary for built environment to remain in stasis, and they have their own conventions. Although agents may contest portions of a built environment, it exists to be shared as a whole. Hence, reaching formal consensus is an important aspect of the environmental game (Habraken, 2000: 29).

So how can the design of the built environment encourage people to take responsibility in relation to natural processes in a way that promotes rather than restricts environmental homeostasis?

The sociologist Zygmunt Bauman observed that new patterns of mobility among 'global citizens' encourage a shedding of responsibility for the consequences of their actions (Bauman, 1998: 9). He therefore contends that one of the "prime secretes of a 'good city' is the chance it offers people to take responsibility for their acts 'in a historical unpredictable society'" (Bauman, 1998: 46).

By designing built environments that reveal rather than hide the links between people's actions and their consequences, in relation to natural processes[32], a more ecologically responsible behaviour can be promoted. In order to achieve this, the introduction of natural processes into the built environment must be directly related to people's actions. As Habraken explains;

> To understand environmental structure, elements and configurations must be designated in ways that relate to the actions of agents. Because transformation results from agent action, it highlights parts and configurations under agent control. That control, in turn, defines the units of transformation (Habrakn, 2000: 17).

Habraken explains how environmental transformations highlight agents' control over parts of the environment. These control patterns, which are linked to agents' actions, and are a result of environmental transformations, can lead to a certain level of responsibility for the environmental parts under control. Responsibility may more easily emerge in 'private' places, where consequences of actions directly affect people's everyday lives, but it can prove to be more elusive and difficult to achieve in the public domain. Habraken illustrates how people negotiate space in the public domain;

> The human body implies territorial presence. Therefore, being in a public space is partaking in a game of instant territorial reconfiguration, shifting as people use things: sitting on benches, waiting for buses, parking cars,

[32] Revealing the links between actions and consequences, through the built environment, can be promoted not only in relation to natural processes, but also in relation to other social and economic processes, but this is an argument which is beyond the scope of this thesis.

> entering telephone booths, standing by the sidewalk. A game of fleeting spatial claims and territorial inclusions follows the flow of use within the contextual setting of a given public space (Habraken, 2000: 160).

The negotiation of space in the public domain seems to imply a fleeting relationship between people and the space they occupy at a certain point in time. Unlike particular private places (and a 'private' place can also exist within the public domain, like one's work-place), public spaces will be characterised, in the context of this argument, by the fleeting nature of people's engagements with them. So how may responsibility for one's actions be generated within the pubic domain?

Various architectural experiments have proven that participation in the planning process tends to generate a sense of ownership and responsibility towards a place within a specific community (Blundell Jones et al., 2005). However, in cases where participation in the planning process is not possible, can personal and collective responsibility towards a shared place be generated through the use of social feedback mechanism?

In public places, the role of Habraken's third order – that of social consensus, becomes highly significant, not only for the way in which public places are initially generated and built, but also for the way in which they are maintained over time. Social consensus can help to counter-balance actions of users who do not follow collective environmental "rules", and the ability to do so should be supported by the design of the built environment. One example may be the treatment of waste in public places. The current prevailing method for recycling in public places is by providing different types of bins for different types of waste. The responsibility for emptying the bins and collecting the waste into recycling centres lies solely with the authorities. The link between the waste generated in a specific place and its consequences on the world is barred to most people. A different relationship between the actual waste generated by people in a specific public place and its consequences can be generated by a different design of both the waste collection system and the architectural environment. For example, organic waste can be thrown straight into the ground (enabled by appropriate design), and its influence on the soil in a specific environment can also be revealed through information screens or other means. This will encourage users' personal responsibility for their actions, simply by revealing the direct relationship between their actions (throwing the waste) and the earth. Irresponsible behaviour can then be publicly condemned (this can be viewed as 'negative feedback' when the irresponsible behaviour must be compensated for in some way). Other systems for various wastes collection can be developed that reveal the direct links between people's behaviour in a specific public place and the consequences of their actions. Incorporating this type of information into the design of the built environment can potentially encourage individual and collective responsibility for natural processes in shared public places.

17.3.3 Conclusions

The discussion in this chapter aimed to introduce the idea of homeostasis into the built environment. It has been suggested that negative feedback can encourage homeostasis in the built environment by designing into it possibilities for regulating people's behaviour in relation to natural processes in the environment. Homeostasis between people and natural processes may be more easily reached in private places, where the consequences of one's actions become apparent and encourage personal responsibility. However, in public places, homeostasis may be more complex and difficult to achieve as more and more users become involved in the environmental regulation process. It has been suggested that negative feedback can be introduced into public places through social consensus and its explicit "enforcement" which may enable the regulation of collective environmental responsibility.

17.4 General Conclusions – Relational Dynamics

The idea of relational dynamics between people and natural processes as part of the built environment has been distinguished in relation to three ecological principles that illuminate the relational dynamics within living systems.

1. *Positional value* – the first principle distinguishes between the different possible positional values of people and architecture within the built environment. People's positional value can be determined by their frequency and type of involvement with a given context, while architecture's positional value can be determined by the type of relations that it facilitates between people and natural processes within a given context.
2. *Feedback mechanisms* – the second principle utilises the different positional values of users and architecture to design appropriate feedback relations between people and natural processes within the built environment, according to the different levels and frequencies of engagement that people are likely to have with the built environment at a given context, and the nature of that engagement.
3. *Homeostasis* – the third principle refers to the tendency for homeostasis in living systems, which can be regulated, to some extent, within the built environment, by the use of negative (counteracting) feedback. Negative feedback may be introduced into the built environment by revealing direct links between users' actions and their consequences on natural processes. A regulation process can then take place through personal and collective responsibility for actions within the environment.

The next chapter will examine the possible implications of positive feedback between people and natural processes on the built environment.

18. The principle of Emergence

The principle of emergence describes the phenomena of growth in living systems, which is characterised by the formation of new organisational levels within a system. According to Laszlo, there are two important aspects that describe emergent properties:

> first, they are lost when the system breaks down to its components - the property of life, for example, does not inhere in organs once they are removed from the body. Second, when a component is removed from the whole, that component itself will lose its emergent properties - a hand, severed from the body, cannot write, nor can a severed eye see (Laszlo, 1997: 9).

Applying the principle of emergence to architecture is a difficult task. It challenges existing notions of planning and design, which tend to follow a linear progression from a conception of an idea all the way to its implementation in form. The following discussion will aim to explore whether the principle of emergence can be applied to the built environment, and if so then how. It will proceed through the investigation of three main ecological principles which characterise emergence in living systems: (1)Holarchy, (2)Increasing complexity and (3)Self-transcendence. Each one of them will be explored in turn in regards to its possible applications within the context of the built environment.

18.1 Holarchic organisation in the context of the built environment

Holarchic organisation in living systems refers to their tendency to grow from the bottom upwards, such that 'lower' level components interact until they create a 'higher' level organisation which includes new, usually more complex properties. Holarchic organisation also entails that each part of the system reflects the whole ('holon'). Applied to the built environment, the notion of holarchic organisation implies the development of the architectural system in a gradual, bottom-up manner, such that one level defines the formation of the next level and so on... instead of being designed primarily through an imposition of a plan by the architect alone. Bookchin describes this as a transition from a way of thinking of "what-is" to "what-it-is-not:"

> We require a way of thinking that recognizes that "what-is" as it seems to lie before our eyes is always developing to "what-it-is-not," that it is engaged in a continual self-organizing process in which past and present, seen as a richly differentiated but shared continuum, give rise to a new potentiality for a future, ever-richer degree of *wholeness* (Bookchin, 1993: 5).

The notion of holarchy therefore implies a transition from a world of certainty to a world of uncertainty and continuous unfolding. In order to support holarchic organisation within it, the built environment must first of all be planned to support, rather than restrict, unanticipated interactions to take place within its boundaries, which may lead to the emergence of new forms.

18.1.1 Encouraging unanticipated interactions within the context of the built environment

Current prevalent design and planning methods encourage function-specific designs, according to which planners and designers formulate and fix highly specific programme prior to design, which is then translated into built form. The result is that an initial programme which is derived from a single point in time determines a highly fixed, unchanged form. The resulting built form, "rather than suggesting broad architectural possibility for inhabitation, limits the capacity to the one function that is intended, in an approach that ignores the iterative nature of the process of mutual self-definition of form and inhabitation" (Habraken, 2000: 135). As Habraken points out, current function-driven architectural designs do not leave much space for user alteration and appropriation of the built form and therefore interfere with the natural process of inhabitation. Kroll compares this prevalent type of planning to colonialism;

> When planners divided up the infinite diversity of human activities, assigning them to a series of precisely defined zones and reducing them to classifiable types, this was nothing short of colonialism (Kroll, 1986: 5).

Kroll argues that instead of encouraging various ways of inhabitation and appropriation of the environment according to individual needs, planners and decision makers have slowly become 'dictators' of space, leaving little room for individual flexibility. Even on a bigger scale, such as that of a neighbourhood or a city, certain centralised acts have consequences for the formation of spatial organisation. Kroll explains how the delivery of essential services, such as electricity and sewage, dictate the way in which space is formed in cities;

> Such 'services' [sewage, water, gas, electricity, electronic communications, etc.] tend to bring with them

> irrevocable forms of organisation, always hierarchical, with a tree-like structure, never a network. This can only result in 'sewer landscapes' which may be relieved to a greater or lesser degree with embellishments, but remain lacking in real texture. Such rationalisations were probably inevitable a few years ago, but they have prevented a more essential urban order from crystallising out. Such an order can arise out of group intentions, depends on urban instincts about proximities and scale relationships, and can ultimately knit together a whole territory (Kroll, 1986: 5).

Kroll argues in favour of alternative methods of organisation in the built environment, those that grow from the bottom upwards, rather than centrally imposed, and that can leave room for unexpected situations to arise.

It was through unexpected engagements with stones, for example, that people first discovered fire; and through interaction with plants that people learned how to produce medicine, food, shelter, and so on... An environment which is entirely predictable and planned in advance will be able to offer very few opportunities for unexpected situations to arise within it. It is therefore essential, if we wish to encourage holarchic growth within the built environment, that this environment will be able to provide a variety of possibilities for people to engage with it in an unanticipated manner. This may mean that instead of imposing specific functions on a plan in advance, places can be designed in relation to the unique qualities that they offer the user; one with direct sunlight, one with water, a view to the street, a place to lie down and listen to birds, etc. Places that offer a combination of such qualities, instead of being defined by function, may be able to generate unanticipated activities and encounters between people and natural processes in the environment that surrounds them.

One famous critique of environments which do not provide enough possibilities for unexpected encounters is Jane Jacobs' analysis of American cities. Jacobs found that sidewalks are essential for the health of cities, since they allow a "relatively high bandwidth communication between total strangers, and they mix large numbers of individuals in random configurations... Sidewalks provide both the right *kind* and the right *number* of local interactions" (Johnson, 2001: 94). On the other hand, roads and highways do not provide the same potential for local interactions, because the information they allow to transmit between agents is so fleeting and famished. It is limited by the speed and the distance of the automobile that no higher-level order[33] can emerge (Johnson, 2001: 96). It is therefore essential to consider the right type of platforms within a specific environment which can give rise to emergent relations between people and nature.

18.1.2 Encouraging positive feedback between people and nature in the context of the built environment

Processes of growth and transformation in living systems, which are the generators of holarchy, mostly occur through the utilisation of positive feedback;

> Positive feedback loops, in contrast to those conductive to homeostasis, consist in feedback mechanisms which serve, not to correct deviations from a steady state, but to amplify such deviations, that is, the system reacts on itself to amplify the deviations in the values of its state variables... Positive feedback mechanisms are involved in the processes of growth and death - the major changes to which organic systems are subject (Mathews, 1991: 95).

Processes resulting from positive feedback can lead either to growth and transformation or to chaos and death. A level of risk and uncertainty is therefore inherent to positive feedback, unlike

[33] In the context of this argument, 'higher-level order' refers to the emergence of situations or encounters which are not necessarily anticipated or implied by the initial design.

negative feedback, which is associated with processes of homeostasis. Introducing the idea of positive feedback to the built environment therefore carries with it certain levels of risk as much as it carries possibilities for growth and development. However, positive feedback is considered necessary for a living system to be able to make a 'leap forward' and change its existing configuration. Similarly in the context of the built environment, positive feedback can help to accelerate processes and change an existing structure or system. For example, the planting of flora in several boulevards in Tel-Aviv triggered increased pedestrian movement through them, which in turn encouraged the owners of some derelict existing kiosks to convert them into small cafés, which resulted in a complete revival of the previously desolated boulevards.

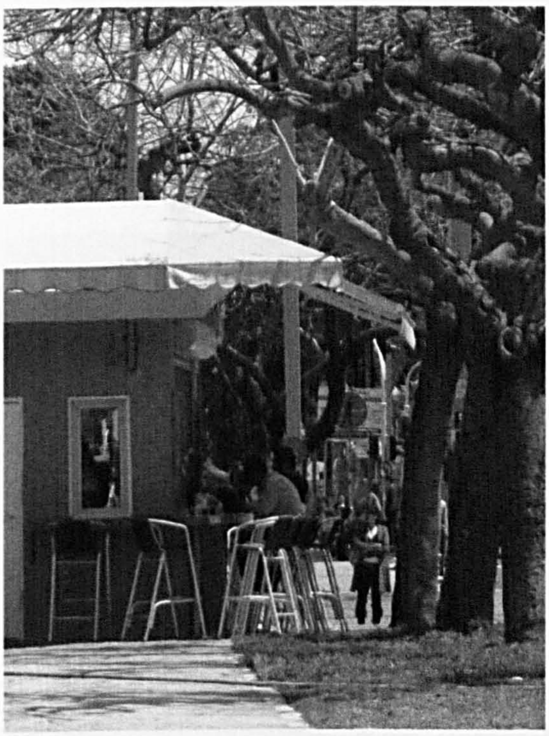

Image 12 – Street Café in Rotshild boulevard, Tel-Aviv, Israel.

The conversion of the old kiosks into new cafés can be considered as positive feedback, since it significantly accelerated the process of the boulevards' revival.

Other types of positive feedback can be introduced within the context of the built environment, to support its revival and that of the natural processes within it. For example, in the case of the Tel-Aviv boulevards, huge amounts of water are needed to keep the flora in tact. A series of actions can be put in place that aim to reveal interrelated water cycles in the area, that can be integrated to form one solution. Firstly, by revealing the amount of water that is actually needed to sustain the flora in the boulevard. Second, revealing the amount of water that is being used by an average household in the boulevard. Third, putting in place a grey-water harvesting system for selected households in the boulevard that agree to take part in the experiment. Fourth, utilising the harvested water from the selected households to water the boulevard's flora. Fifth, rewarding the participating households. This kind of experiment may or may not trigger a positive feedback process that can transform the entire water-usage system in the boulevard, by integrating private use patterns (of the boulevard's residents) with contextual, public use patterns.

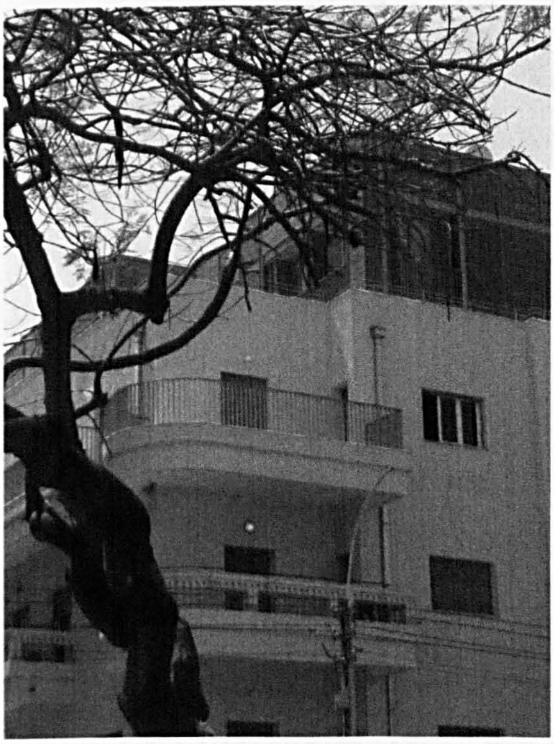

Image 13 –Housing block in Rotshild boulevard, Tel-Aviv.

The principle of positive feedback is being utilised in various ecological approaches for restoring and accelerating natural processes. One of these approaches is the *Permaculture* farming system, which has extended beyond farming to encompass a model for a sustainable lifestyle (Pearson, 1995: 74). One example of a positive feedback process used in permaculture is

> the use of fast growing nitrogen fixing trees to improve soil, and to provide shelter and shade for more valuable slow growing food trees, reflects an ecological succession process from pioneers to climax. The progressive removal of some or all of the nitrogen fixers for fodder and fuel as the tree crop system matures shows the success. The seed in the soil capable of regeneration after natural disaster or land use change provides the insurance to re-establish the system in the future (Holmgren, 2004: 18).

Permaculture practitioners agree that by "correct placement of plants, animals, earthwork and other infrastructure it is possible to develop higher degree of integration and self-regulation without the need for constant human input in corrective management" (Holmgren, 2004: 14). The main idea behind permaculture is, therefore, that by re-learning to work with natural processes, human societies can become re-integrated with the self-regulation mechanisms of nature. Positive feedback processes can help to re-generate systems and processes that may have become unproductive and lack self-regulation mechanisms. In that sense, positive feedback is a way of injecting new life into a decadent system. According to permaculture, processes of change are not desirable per-se, but only in a context which deems them necessary;

> In any particular system, the small-scale, fast, short-lived changes of the elements actually contribute to higher-order system stability. We live and design in a historical context of turnover and change in systems at

> multiple larger scales, and this generates a new illusion of endless change with no possibility of stability or sustainability. A contextual and systemic sense of the dynamic balance between stability and change contributes to design that is evolutionary rather than random (Holmgren, 2004: 18).

Positive feedback processes are therefore best introduced in instances where change is needed in order to generate contextual self-regulation, which may lead to overall evolution and stability. Introducing positive feedback processes from this perspective may help to minimise the destructive and chaotic affects that are associated with positive feedback.

18.1.3 Conclusions

The discussion in this chapter aimed to introduce the idea of holarchy into the built environment. It has been suggested that in order to promote holarchy in the context of the built environment, opportunities for unanticipated interactions between people and their surrounding environment should be encouraged rather than restricted. Positive feedback can help to accelerate change by encouraging new connections between apparently unrelated processes. However, it has been stressed that processes of positive feedback prove to be most beneficial when applied in order to enhance larger, contextual self-regulation capacities. Positive feedback mechanisms encourage the formation of holarchy by enabling processes to grow and develop unpredictably in a bottom-up manner rather than being imposed from above as "one-off" solutions.

The discussion in the next chapter will examine how holarchy can be manifested through the principle of increasing complexity.

18.2 Increasing Complexity in the context of the built environment

Increasing complexity in living systems refers to their tendency to develop into more and more complex systems as they evolve. Their degree of complexity is apparent through *distinction* and *connection*, which means that a system's parts will tend to become more distinguished from one another as well as more connected to one another at the same time, as the complexity of the system grows. An increase in complexity for a living system tends to suggest a better chance of survival (resilience) and a better capacity of adaptation to its environment (Heylighen, 1996).
In the context of the built environment, an increase in complexity for architecture may be reflected through an increase in connectivity between the various structures and systems that form the built environment, as well as an increase in their distinctive qualities. The possibilities for achieving this will be explored in the following discussion, with a focus on the relations between the built system and natural processes.

18.2.1 Increased connectivity in the context of the built environment

Living systems generally tend towards increasing their complexity, but human interference with their natural activity may disrupt this tendency in various ways. For example, natural soil in urban areas may, in fact, become less fertile over time because its environment does not provide any stimulation for an increase in complexity. In order to meet their natural tendency to become more complex, living systems need constant interaction with an environment which encourages them to develop, by being more complex, and therefore requiring the system to increase in complexity simply in order to maintain its fitness relative to the systems it interacts with (Heylighen, 1996: 28).

Built environments, in their current, modern state do not offer a very rich context for human beings, as living organisms, to evolve in, and in that sense, the degree to which they stimulate us to 'increase our complexity' is questionable.

So, how may built environments be planned to encourage an overall increase in complexity? And to what degree is an 'increase in complexity' desirable?

It has been argued in the second section of this thesis that one of the main drawbacks of sustainable architecture, in its current state, is that it does not (yet) fully encompass technology in a way that promotes ecological solutions. In most cases, 'sustainable technologies' are applied within the context of the built environment in ways that promote "development" (the development of what? the economy?). This implies the application of linear, mechanistic solutions, which are driven by scientific notions of progress. These types of solutions, in most cases, restrict and contradict ecological, emergent evolution of living processes, including human societies. The principle of increasing complexity, which is characterised by increased *connectivity* and *distinction* can provide some kind of ecological benchmark for the success of certain solutions, viewed in relation to natural processes. It may therefore be assumed that, in the context of the built environment, increasing connectivity between built systems, human behaviour and natural processes is one way of assessing the degree of success of certain solutions. In this way, the 'evolution' of the built environment can correspond to the 'evolution' of natural processes, by integrating the two into one system. These can be exemplified in different architectural patterns or systems which integrate natural processes into the built environment[34].

One example of such an architectural pattern may be that of a green roof. By repeating the pattern of a green roof within a local neighbourhood, a system of green roofs may be generated which has the potential to significantly enhance the local ecological system within that context. The higher-level formation of an urban-ecological green roofs system, which is formed as a result of repetitive acts of one specific pattern or system within the environment, can enhance and increase not only the complexity of the natural-ecological system within that context, but also the complexity of the overall built environment.

It therefore may be assumed, that by developing architectural systems which allow a variety of configurations in incorporating natural processes into them, their potential to be spread widely within the built environment and to create higher-order architectural systems on an urban level, may be enhanced. An increased connectivity may then occur within the built environment on two distinct levels:

(1) One is the level of the built system itself, which incorporates natural processes into it, (i.e. through the green roof this is evident in the additional use of soil, different types of flora which can attract insects or other small animals that become new users of that environment).

(2) Second is the higher-order, urban level, which now incorporates a system of green roofs into it, which can spread to the level of a street, neighbourhood, district or even a whole city.

[34] For a discussion about the differences between built patterns and built systems which incorporate natural processes into them see section 16.2.2

The other possibility for an increased connectivity within the built environment, which follows from the argument brought forward in this thesis, is on a human-behavioural level. How may the built environment help to reveal or facilitate the connection between human actions and natural processes? Is it possible, through an increase in complexity, to increase the connectivity between actions and their consequences on nature?

The importance of human activity and the individual responsibility for those activities is considered by some to be essential for achieving sustainability in the long run. Manzini (2004) refers to design solutions which encourage personal responsibility as 'enabling solutions.' According to Manzini, a sustainable solution differs from a sustainable technology in the sense that it aims not only to produce an 'ethical product' but also to promote sustainable behaviour. A sustainable solution, then, is "the process by which products, services, and know-how are made into a system with the aim of facilitating the user in achieving a result coherent with sustainability criteria" (Manzini, 2004: 1). A sustainable solution is not only aimed at producing a 'final result' which is sustainable, but one which also has the effect of "transforming the given system and generating a new one which is characterised by its consistency with the fundamental principles of sustainability, by a low energy and material intensity and by a high regenerative potential" (Manzini, 2004: 1). The last words are probably the most significant and insinuate the involvement of the user in a continuous regenerative cycle, which makes the system sustainable in the long run. Manzini then goes on to specify that the regenerative potential of a solution refers to its capacity to modify, positively, the state of things, by integrating with its context, enhancing local environmental and social resources. Part of the success measure of such regenerative solutions, according to Manzini, is their capacity to give users the tools and knowledge they need to achieve their skills and abilities to the best advantage. He defines such regenerative solutions as 'enabling solutions,' since on top of their regenerative capabilities they enable users to act (Manzini, 2004: 4). The importance of Manzini's contribution to the concept of sustainable solutions is in stressing the educational and evolutionary nature of these solutions, i.e. the technology or product itself is insignificant in its influence on the over-all sustainability goals unless it manages to enhance people's individual and collective capacity for development.

It can therefore be maintained that an 'increase in complexity' in relation to human activities may refer to a gradual increase in people's respective awareness, responsibility and action, which arise out of their enabled interaction with the environment. By designing 'sustainable solutions,' such as those that Manzini describes, the behaviour of people may change accordingly through their interaction with these types of 'enabling' solutions.

The potential of using physical systems and environments to encourage sustainable behaviour is considered to be greater than using intellectual communication, because they engage us on physical and perceptual levels. It has been proven in past experiments that physical presence of objects has a stronger influence on people's behaviour than signs. For example, speed bumps alter drivers' driving speed more efficiently than "slow down" signs; the reason being that the speed bump physically compels drivers to stop, while the sign only recommends it. Perceptions and actions always have an aspect of sensorial contact with reality, which is precisely the point of application for mediation by material artefacts (Verbeek, 2005: 209). The conclusion may be that certain designs can encourage people to behave differently - in a way which will gradually increase their awareness of the processes that they come into contact with, and generate a different type of behaviour - one which can possibly be more sustainable and more sensitive to natural processes.

Designs which encourage an 'increase in complexity' in relation to people's actions can be regarded as designs which enable people to become more *aware, responsible, and engaged* with the environment through them, over time, and not in a way which disrupts or distracts people's attention from the interdependent nature of environmental processes.

18.2.2 Increased distinction in the context of the built environment

The notion of increased distinction may initially seem contradictory to the ideas of emergence, holarchy and evolution, which tend to imply integration rather than distinction. But the fact is that as living systems evolve, they become more coordinated in their actions and as a result – distinctions between them arise. This is exemplified in any organism as it evolves from an embryo into a fully developed creature - the distinctions between its different organs and life-supporting mechanisms become clearer and clearer. Similar evolutionary processes can be applied within the context of the built environment. Instead of determining beforehand how each architectural system will perform in a specific context, systems can be designed in such a way that enables users to appropriate them according to their specific needs and in relation to other processes in the environment. This may entail that initial infrastructures can be laid out, in a way that opens up possibilities for users to adapt and interpret them according to their own needs over time.
Gutman distinguishes between three different types of structures within the environment - existential structures, operational structures, and organisational structures:

> *Existential structures* are those in which the parts have the least freedom (e.g. spider web, bird nest, a bridge, a building, furniture etc.); in these the relative *positions*

> are permanently fixed. *Operational structures* are ones in which some or most of the parts have a limited freedom of movement (e.g. man-made machines and instruments); in these the *pathways* of moving parts are more or less fixed. *Organizational structures* are those in which most of the parts have relatively large freedom of movement within the boundary of the structure, in some instances even in and out of the boundary (e.g. living organisms on the cellular level and social organizations of animals and men); in these not even the pathways are fixed although the *roles* that these moving parts play are usually well defined. Living systems start out as organizational structures. In their evolution or development, they make increasing use of operational and existential structural elements (Gutman, 1969: 229).

The three different types of structures that Gutman describes may inform the design of the built environment. Instead of designing primarily existential structures, whose parts are fixed and relatively inflexible, it may be better to try and design architectural systems that start out as organisational structures (with the highest degree of flexibility) and slowly make more and more use of operational and existential structures as they 'evolve' to suit location-specific needs.

One architectural method which aims to promote a more flexible approach to buildings is the 'open building method,' which was initially developed by a group of Dutch architects. According to this method

> Form is considered in terms of possibilities rather than in terms of a single, rigid and predetermined function. This in turn reinforces the concept of levels; a form (e.g. base building) may be judged based on its demonstrated capacity to accommodate multiple arrangements of lower level forms (e.g. alternate uses and interior layouts). Rooms exhibit capacity to allow multiple furniture arrangements and activities, and urban tissues may maintain coherence while accommodating a variety of building types and styles (Kendal & Teicher, 2000: 38-9).

The 'open building method' relies on a stratified notion of environmental levels, which proceed from a stable urban collective level to a more flexible individual level.

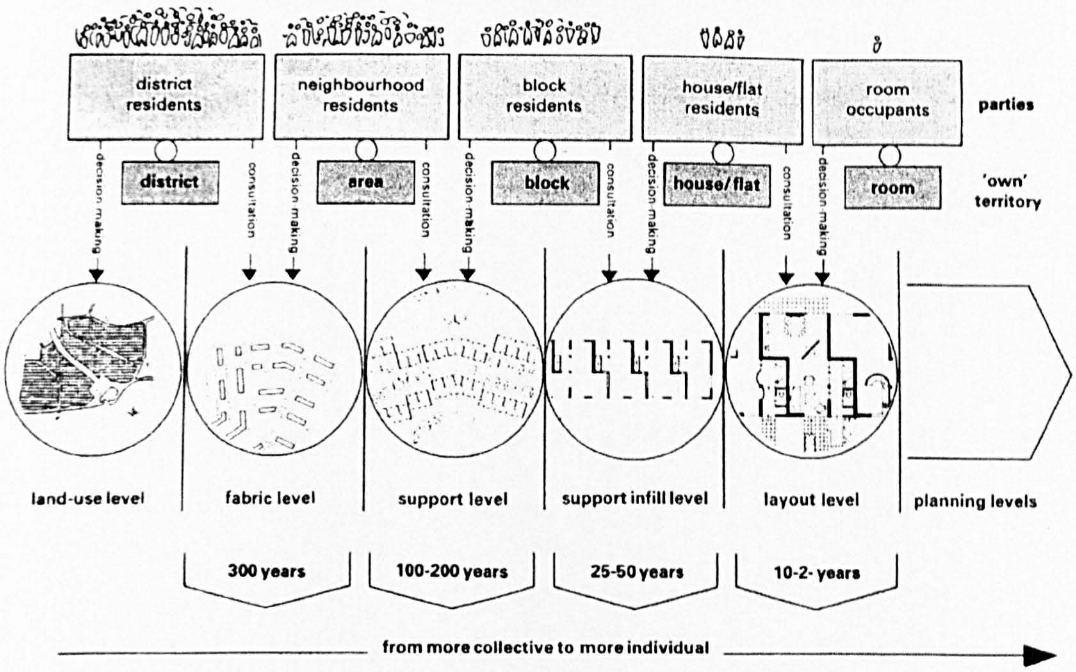

Diagram no.12 - Illustrating levels within the built system (Kendal & Teicher, 2000: 6)

The result is a formulation of a design tool which promotes stability on the larger scale and change on the smaller, individual scale. Although the 'open building method' promotes flexibility at the 'lower' levels, this flexibility cannot permeate "upwards" to more collective levels of the built environment and change them. In other words, it restricts change only to certain levels, and this change cannot affect the structure of the bigger system of which it is a part. This type of flexibility does not correlate with flexibility in living systems, which can lead to emergence and to an increase in complexity of the system as a whole. In order to support emergence, users' actions at every level of the built system should be able to lead to change in levels 'higher' than the level at which they operate. This may mean that changes at an individual layout or infill levels can generate further changes at the support and fabric levels of a street, neighbourhood or a district. Designing structures and services (at every level) that function like organisational structures can provide more potential for flexibility at various levels of the built environment. As they begin to be occupied and used, these organisational structures can then become more and more distinct in the way they operate, by making use of operational and existential structures. One of the advantages of a stronger distinction between architectural systems is that it promotes diversity in the built environment. As Kroll observes;

> It is obvious that the redecoration of a single door in a uniform line of houses by the occupant is a stark political gesture requiring exceptional courage, but if everything is diverse and varied rather than uniform, then timid interventions can gently be made which encourage others of a bolder nature. A process of accretion starts, which grows like a biological organism (Kroll, 1986: 30).

Kroll suggests that a diverse environment offers more possibilities to generate change than a uniform one, and in that sense, operational and existential structures which are individually adapted to their users and to their local conditions, will automatically generate diverse and unique architectural environments. This entails that an increased connectivity between users' behaviour, natural processes and the built system can lead, over time, to an increased distinction between various architectural systems, which can generate an overall increase in complexity of the built environment.

18.2.3 Conclusions

The discussion in this chapter aimed to introduce the principle of increasing complexity into the built environment. It has been suggested that an increase in complexity within the context of the built environment can be generated by increased connectivity between the built system and natural processes, coupled with the design of 'enabling solutions' that aim to generate increased connectivity between people's actions and natural processes, through the built system. Increasing complexity is characterised by an increase in connectivity as well as distinction. Increased distinction, in the context of the built environment, can be generated by the design of built systems that initially operate like organisational structures, i.e. providing a high degree of flexibility for people to appropriate them according to their needs, and in relation to natural processes. As the process of appropriation and inhabitation takes place, organisational structures transform to accommodate operational and existential structural elements, which add to the distinction and uniqueness of the architectural system.

The next chapter will examine how the principle of self-transcendence may be apparent in the context of the built environment as a way of identifying emergence.

18.3 Self-Transcendence in the context of the built environment

Self-transcendence in living systems is the process by which a system transcends its own structure to result in a new, usually more complex organisation. Self-transcendence occurs as a result of two processes. One is *heterogeneous cooperation* where several non-similar systems cooperate to create a new system. The second is *homogeneous cooperation* where one system duplicates itself and then differentiates to create a new type of a more complex system. In the context of the built environment, the two processes which lead to self-transcendence will be explored in the following discussion in order to clarify how emergence may be identified within the context of the built environment.

18.3.1 Self-transcendence of the built environment through heterogeneous Cooperation

The process of heterogeneous cooperation in the context of the built environment can refer to emergent processes in which all of the participating systems are transformed as a result. This may entail that a higher-order level emerges within the built environment which is composed of several differentiated processes, i.e. it can include built systems or structures, natural processes as well as behavioural processes – all of which are transformed in the emergent process.

The discussion about 'increasing complexity' in the previous chapter illustrated how emergent processes may include the integration between built systems and natural processes to result in a new higher-order architectural system. It also illustrated how 'enabling solutions' may trigger the emergence of new behavioural patterns within the built environment. The process of heterogeneous cooperation within the built environment therefore refers to situations where the combination of two or more of these processes (i.e. built systems, natural processes, and behavioural processes) results in a new configuration.

Latour's 'actor-network theory' may be useful at this point in illustrating this type of "self-transcendent" process.

According to Latour, human interactions with 'things' generate a "meeting point" which has the potential to transform both the people interacting as well as the things with which they interact. He gives an example of a person that buys a gun. The person may be harmless without the gun in his possession, but when he is in possession of the gun, there is a bigger chance that he might cause damage with it. Similarly, the gun itself is meaningless until a person pushes its trigger. Therefore, both the gun and the person change in the mediated situation: the person is different with the gun than without, and the gun is different with the person than without. The focus is on the situation itself – the "meeting point" between the tool and the person, or the mediation, as Latour refers to it. According to Latour, neither the person nor the gun has an "essence" - they have existence and they are transformed in their relation to one another;

> Mediation thus consists of making possible a new program of action that arises out of relations that actants[35] have to each other. This means that mediation always involves several actants that jointly perform an action. Responsibility for that action, therefore, is spread out over the ensemble of parts (Verbeek on Latour, 2005: 156).

Latour suggests that the responsibility for an action should be spread equally among actants, whether conscious of it or not, for the simple reason that the impact of artefacts on humans is just as

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[35] By 'actants' Latour refers to the actors that participate in the interaction.

significant as vice versa. Verbeek argues, like Latour, that things carry morality because "they shape the way in which people experience their world and organise their existence, regardless of whether this is done consciously and intentionally or not. The very fact that they *do* this shaping charges designers with the responsibility to make sure that things do this in a desirable way" (Verbeek, 2005: 217). By referring to Latour, Verbeek introduces an important discussion about the ethicality of artefacts and the complexity of the process of assigning responsibility for some consequences of actions that arise from using artefacts. Since the process of interacting with artefacts is a process which can not be entirely anticipated in advance, because both a person and an artefact may be transformed as a result of the interaction, then it becomes increasingly difficult to assign responsibility for the consequences of these actions to the designer of the artefact alone. This discussion is relevant for the idea of heterogeneous cooperation because it begins to acknowledge the possible significance of artefacts or built systems in generating new, emergent, unanticipated conditions in the environment. By integrating natural processes into the design of artefacts and architectural systems, their possibilities for generating new conditions in the world may be enhanced in correlation with natural processes within a specific locality.

In his book 'The Politics of Nature' Latour argues that one of the significant roles of the ecology movement was the suggestion to incorporate natural, nonhuman entities into the social realm. He then goes on to suggest the possibility of including non-natural objects as well within the social collective.

> As soon as we stop taking nonhumans as objects, as soon as we allow them to enter the collective in the form of new entities with uncertain boundaries, entities that hesitate, quake, and induce perplexity, it is not hard to

> see that we can grant them the designation of actors. And if we take the term "association" literally, there is no reason, either, not to grant them the designation of *social actors* (Latour, 2004: 76).

The relevance of Latour's theory to the discussion about ecological architecture is in reconsidering the significance of built systems, artefacts and technologies within the built environment and the wider social realm. Instead of employing various 'sustainable' technologies as sole architectural solutions to environmental problems, technologies and other artefacts are viewed as (more-or-less) equal actors in the environmental game. Therefore, by encouraging various heterogeneous cooperations within the built environment, which include natural processes, behavioural processes as well as built/technological processes, higher-order solutions may be generated which incorporate all of these processes into the built environment.

The idea behind Latour's theory can inform architecture as a process by which the aim is not to 'objectify' natural processes and people in the same way that technological systems are objectified within architecture, but rather the opposite; as a process of 'subjectifying' natural processes and technological processes, in the same way that people are treated as subjects and not as objects.

Latour stresses that "We cannot characterize political ecology by way of a crisis of nature, but by way of a crisis of objectivity. The risk-free objects, the smooth objects to which we had been accustomed up to now, are giving way to risky *attachments*, tangled objects" (Latour, 2004: 22). This implies an increased responsibility attached to the built environment, as way of creating heterogeneous co-operations between previously unattached processes – natural, behavioural and technological. By making explicit the possible entanglements between these three processes, through the architectural environment, a new, more complex environmental system may arise; one which incorporates these three distinguished processes into one unpredictable system.

18.3.2 Self-transcendence of the built environment through homogeneous Cooperation

The process of homogeneous cooperation in the context of the built environment can refer to emergent processes in which one architectural system (ideally composed of several interrelated processes, which may include natural processes and behavioural processes) is duplicated and differentiated to suit its context. This may entail that a higher-order level emerges within the built environment which is composed of the repetition of one type of architectural pattern or system. One example which illustrates homogeneous cooperation within the built environment, is that of the formation of portico in northern Italian cities;

> Each house would cover the sidewalk by means of columns supporting the upper façade. The resulting portico would align with neighbours', thereby contributing to continuous covered pedestrian network throughout the town. Thematic interpretation varies at each house. Columns differ in shape, span vary, and so do the heights and spring points of the arches. But throughout the city, these individual acts add up to a collective product, building a virtual urban infrastructure of great architectural power and intricacy. The resulting form bears the qualities of two levels. It structures the townscape by virtue of continuity, but it retains variety in size, detailing, and arcade span, hallmarks of individual interpretation. Façade alignment makes the whole more than the sum of the parts (Habraken, 2000: 242).

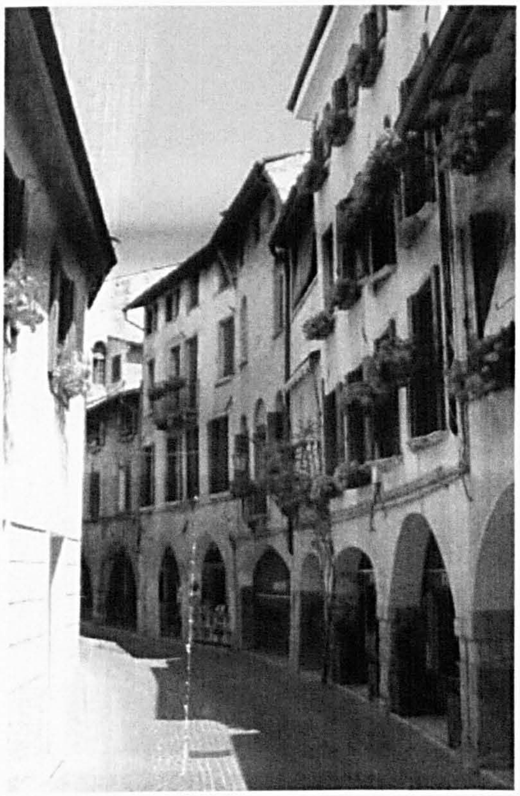


Image 14 - Italian street with Porticos (www.willemswebs.com/album/asolo/asolo1.jpg)

In this case, self-transcendence occurs through individual interpretations of the built pattern (i.e. the portico), which is duplicated and then differentiated to suit individual needs and tastes. The result is an architectural environment which is formed gradually, through homogeneous cooperation, and which could not have been anticipated in advance or imposed in the same way through a central plan.

As part of the principle of emergence, self-transcendence implies that new properties arise at the higher-level which were not necessarily apparent at the lower level (Hayles, 1996: 147). This brings into the environment an element of unpredictability and uncertainty.

> Political ecology does not shift attention from the human pole to the pole of nature; it shifts from *certainty* about the production of risk-free objects (with their clear separation between things and people) to *uncertainty*

> about the relations whose unintended consequences threaten to disrupt all orderings, all plans, all impacts (Latour, 2004: 25).

As Latour suggests, this degree of uncertainty may include positive as well as negative consequences for a society which is accustomed to an environmental order that is generally pre-planned and predictable.

The principle of homogeneous cooperation does suggest that the stage of duplication is followed by a stage of differentiation, which means that the duplicated parts are differentiated to create a new type of a more complex system (Sharov, 1998). Just like in the development of an organism, where a cell duplicates and differentiates to create the different organs of the body, homogeneous cooperation in architecture can include a stage of duplication of a certain architectural system, followed by a stage of differentiation, where the different duplicated systems are appropriated to suit the specific conditions in their locality. In this sense, the element of unpredictability can be controlled to an extent and 'tamed' to suit its unique locality. This means that self-transcendence is manifested in the new architectural system at the higher level - the system is not merely duplicated - it is duplicated *and differentiated* which allows it to transcend the initial characteristics of the duplicated system and result in a new, higher-order system which is suited to the newly created conditions.

Manzini presents three self-contradictory conditions, which exist in contemporary society, and which, according to his view sustainability could offer solutions to.

> Scenarios of ways of living in which the search for sustainability becomes the opportunity of proposing a new equilibrium between contradictory demands:
> 1. The demand for individuality and flexibility (i.e. the possibility for everyone to make individually his/her

choices and to define his/her "strategy of life") on one side, and, on the other side, the demand for new sense of community and belonging (i.e. the possibility to escape loneliness, to search for protection and to build an identity, thanks to some new forms of community).

2. The demand for global links (i.e. to share with everybody in the world the experiences of an individual, flexible, mobile life) and the demand for local roots (i.e. to belong to a local community because it can be useful or simply because what emerges is a basic need of socialisation).
3. The demand of being served (i.e. to have access to new forms of full services, and, in this way, to get rid of any commitment and care) and the demand of being empowered (i.e. to have access to enabling platforms, and, in this way, to have the possibility to get some results that, in any case, due to lack of time, tools and knowledge, to be got, require some form of help). (Manzini, 2003: 11)

Designing the built environment in such a way which allows for self-transcendence to take place, instead of imposing pre-determined, rigid plans on the environment, can enhance the possibility of architectural systems to offer solutions to contemporary contradictory conditions, such as the ones which Manzini describes above. Flexible architectural environments, which offer people the possibility to engage with them and in fact – influence their ongoing formation, can encourage environmental designs which are not only more compatible with natural processes, but which are also more compatible with changing human needs in an increasingly connected world. Homogeneous cooperation in architectural systems will allow people to share and spread architectural ideas, not by merely copying them, but by incorporating their own individual needs and ideas into them, and through this process allowing these architectural systems to self-transcend their original designs.

18.3.3 Conclusions

The discussion in this chapter aimed to examine how the principle of self-transcendence may be apparent in the context of the built environment. It has been suggested that self-transcendence is apparent through two main processes. One is the process of heterogeneous cooperation, which describes the possible integration between natural processes, behavioural processes and built systems, to result in a new, higher-order architectural system that takes into account two or more of these processes. The second is the process of homogeneous cooperation, which describes the possible duplication and differentiation of one architectural system within the built environment, which result in a new, higher-order architectural environment. The two different processes that describe self-transcendence can help to illuminate, identify and generate emergent processes within the context of the built environment.

18.4 General Conclusions - Emergence

The principle of emergence within the context of the built environment refers to the evolutionary process of an architectural system. The discussion in this chapter aimed to explore the possible manifestations of emergence within the context of the built environment, according to three main principles:

1. *Holarchy* – the first principle distinguishes how a 'bottom-up' process of development may be encouraged within the built environment by extending the range of possibilities for unanticipated interactions between people and natural processes. This can be encouraged by designing-in to the architectural system opportunities for positive feedback between apparently unrelated processes in the environment.
2. *Increasing complexity* – the second principle describes the process of increasing complexity, which is characterised by an increased connectivity between the built system, users' actions and natural processes, as well as an increasing distinction between various architectural systems, through their gradual appropriation by users within a specific context, to suit individual needs and local natural processes.
3. *Self*-transcendence – the third principle describes how the emergence of a new, higher-order architectural system may occur through two differentiated processes: (1)heterogeneous cooperation, which is characterised by the integration of the built system with natural and behavioural processes, and (2)homogeneous cooperation, which is characterised by the duplication and differentiation of an architectural system.

19. General Conclusions from Section Three

The discussion in this section examined how the understanding of ecological principles may inform architectural design, by focusing on the relations between people ('the users') and natural processes that may be enabled through the design of the built environment.

The different ecological principles, therefore, provided a framework for analysing how architecture may be able to better support an ongoing, dynamic, and evolving relationship between people and nature.

The conclusions suggest that architecture can support a better relationship between people and nature, by providing a variety of possibilities for frequent and transparent interactions between people's everyday actions, within the context of the built environment, and natural processes. The built system, then, can act as a tool that connects users' behaviour with natural processes in the environment.

For architects and designers, this may entail looking for possibilities to interweave built systems and infrastructures with natural processes, in a way that has the potential to enhance the built environment's capacity to regulate itself, in the same way that living systems regulate their own processes, without having to rely on sophisticated technologies and experts' maintenance. It also entails (re)considering how everyday actions, performed by the users of the built environment, can support the maintenance and evolution of both natural and behavioural processes within that environment.

19.1 An outline of the ecological principles within the context of the built environment

The following is an attempt to outline the conclusions from each of the three main ecological principles, and the contribution of each of them to the definition of an "ecological architecture," which is based on an investigation of ecological principles, their behaviour and organisation as it is manifested in ecological, living systems.

1. *Part/Whole* - The first main ecological principle describes what is the basic relationship that exists between the part and the whole within a given system.
2. *Relational dynamics* - The second main ecological principle describes how the dynamics of the relations between the parts and their relation to the whole are manifested within a given system.
3. *Emergence* - The third main ecological principle describes the outcome of the relational dynamics between the parts, and between the parts and the whole, which is the manifestation of growth and evolution in a given system.

In the context of the built environment, the system is defined as the overall environment which includes natural processes, as well as the built system itself, and the users who interact with it.

The following is a summary of the nine ecological principles and their manifestation within the context of the built environment.

19.1.1 Part/Whole Relation within the built environment

(What is this relation?)

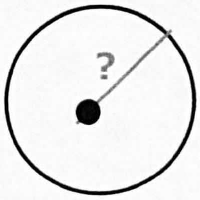


Diagram no. 13 – Part/whole relation

1. *Interdependence* – Architecture as a tool for manifesting contextual interdependencies between people and natural processes.

2. *Purposefulness* – Architecture as a tool for enhancing correlation in purposes between contextual natural processes and functional behavioural processes.

3. *Autopoiesis* - Correlating autopoiesis of humans with autopoiesis of nature through the built environment, by designing possibilities for various interactions between people and nature that may cause "structural changes" in both.

19.1.2 Relational Dynamics within the built environment

(How is this relation manifested?)

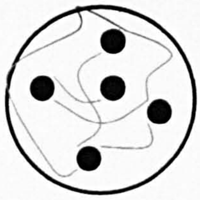


Diagram no. 14 – Relational dynamics

4. *Positional Value* **–** Users' positional value in relation to nature is determined by the frequency and type of engagement with a context; Architecture's positional value in relation to nature is determined by the type of relations that it facilitates between the user and nature (i.e. mediated, alterity or background).

5. *Feedback* – Feedback relations between people and nature can be facilitated and designed according to the different positional values of the users and architecture within a specific context.

6. *Homeostasis* – Homeostasis can be maintained by introducing negative feedback between people and natural processes, through personal responsibility for actions as well as various social regulations.

19.1.3 Emergence within the built environment

(The 'Outcome')

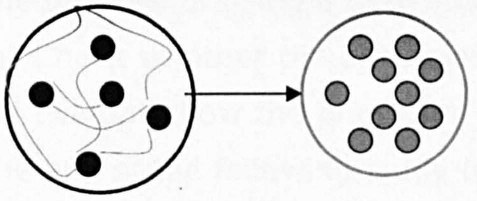


Diagram no. 15 - Emergence

7. *Holarchy* – Encouraging unanticipated interactions between people and natural processes to take place within the built environment can generate holarchy. Positive feedback can accelerate the process by connecting apparently unrelated systems in a way that enhances contextual self-regulation and evolution.

8. *Increasing Complexity* – Increasing complexity is apparent through increased connectivity between people's actions, natural processes and the built system; and through increased distinction between various architectural systems, by designing them initially to perform as organisational structures.

9. *Self-transcendence* – Self-transcendence through heterogeneous cooperation, which integrates built systems with natural and behavioural processes; and through homogeneous cooperation, which is the duplication and differentiation of one architectural system.

The following section will begin to formulate an understanding of the ecological principle within a specific context of a case study.

20. Applying the ecological principles to a case-study

The purpose of using a case study at this stage of the research is to:
(a) Check whether the principles can be applied systematically
(b) Evaluate how the principles work or do not work in practice.
The aim of the following study is therefore to conduct an analysis of the ecological principles within a specific context rather than to offer concrete design solutions.
Yin describes the case study as "an empirical inquiry that investigates a contemporary phenomena within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin, 1994: 13).
Langrish (1993: 361-2) describes several rationales behind the choice and use of a case study:

1. Comparative
2. Representative
3. Best practice
4. Next door
5. Unusual example
6. Taxonomic

In the context of this research, the important criteria for choosing a case study was that it would provide a possibility to investigate the applicability of the ecological principles within an existing urban district or neighbourhood. Choosing an urban context which was 'typical' or 'representative' seemed appropriate in this case, since it would test the relevance of the ecological principles' applicability to any existing environment, not necessarily only a sustainable, 'best practice' one.

The chosen case study is therefore a typical, terraced-house, residential London street - 'Hanley Road'. It was chosen because it fulfils the 'next door' as well as the 'representative' criteria.

Image 15 – Hanley Road, London N4

Hanley Road is situated within Finsbury Park in North-east London. It is primarily a residential street, including a mixture of privately owned and social housing. The population comprises a rich mix of low-to-mid incomers, including young professionals, families and elderly people.

The dominating architectural style is the Victorian terraced house with several more recent, mid-twentieth-century buildings. There are a few public buildings in Hanley Road, which include: an old church, a couple of NHS centres, and several converted shops and offices with flats above them. Most buildings are no more than 3-4 stories high. The road is relatively wide, and the sidewalks are outlined with large trees along the entire street. This makes Hanley Road feel quite 'airy' and pleasant to walk along. There is one bus that passes through Hanley Road, and several bus stops. The amount of cars that drive through is medium and the road is generally not very busy. Pedestrian movement is also medium and tends to increase at both ends of Hanley Road, where it meets Stroud green Road (the neighbourhood's high street) and Hornsey Road, which is relatively busy.

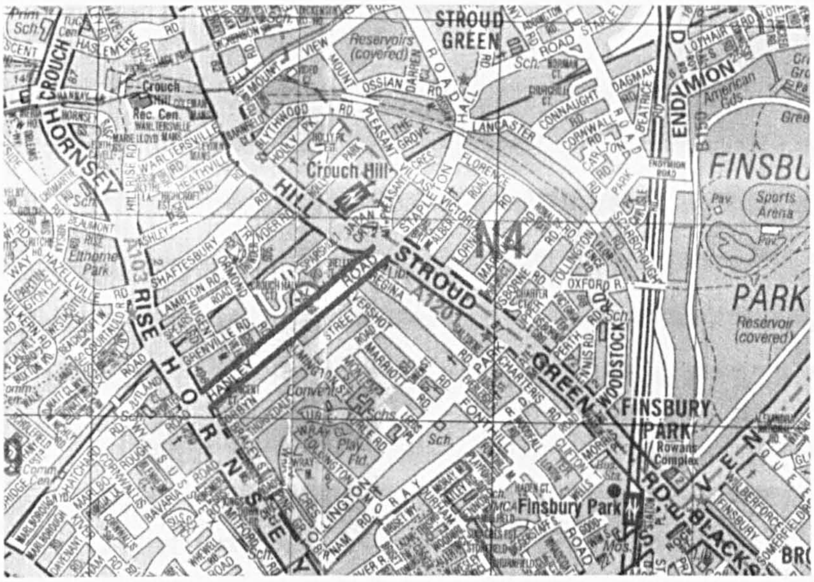


Image 16 – Location of Hanley Road

The study will proceed by testing the possible applications of each one of the ecological principles within the chosen context, in accordance with the theoretical analysis that was conducted in section three. This means that each one of the ecological principles will be analysed according to the way in which it facilitates a relation between the users of the specific context and natural processes in that context. Connections and overlaps among the principles may become apparent as the analysis proceeds. As Stake points out, the observations within a case study "cannot help but be interpretive, and [our] descriptive report is laced with and followed by interpretation. [We] offer opportunity for readers to make their own interpretations of the case, but [we] offer [ours] too" (Stake, 1995: 134).

20.1 Part/Whole relation within Hanley Road

The part/whole relation between people and nature, within the context of the built environment, refers to the attempt to correlate between human actions and natural processes within the environment.

In the context of Hanley Road, certain activities that take place within it will be differentiated, and the degree of their correlation with natural processes in the environment will be explored.

The three ecological principles that help define the part/whole relation - (1)Interdependence, (2)Purposefulness, and (3)Autopoiesis will be used respectively as stages in the analysis.

20.1.1 Interdependence within Hanley Road

Are there any interdependencies currently evident between the users of Hanley Road and natural processes? An initial mapping of the current users of Hanley Road, natural processes in the neighbourhood and possible interdependencies between them is attempted in the following table.

The following analysis is suggestive only and not definitive. Its purpose is to illustrate possible existing interdependencies at Hanley Road, which are based on generalisations and not on precise conditions that may vary among individual users.

–	Indicates no apparent interdependence
+	Indicates a low degree of interdependence
++	Indicates a medium degree of interdependence
+++	Indicates a high degree of interdependence

Natural processes / **Users**	Soil	Water	Sun/energy	Air/wind	Fauna	Flora
Residents	+	++	++	++	+	++
Pedestrians	–	–	+	+	–	+
Cyclists	–	–	+	+	–	+
Drivers	–	–	–	++	–	–
Service providers	+	+	+	+	–	+
Employees	–	+	+	+	–	+

Table no.16 - Interdependencies between users of Hanley Road and natural processes

Interdependencies between users and natural processes refer to these relations which imply mutual dependence of the two on one another. For example, drivers may not be very much affected by air/wind, but their influence on air quality at Hanley Road is higher than that of other users. Therefore, their degree of interdependence with air/wind processes at Hanley Road is considered to be significant. Residents, on the other hand, may not have such a negative affect on air quality at Hanley Road as much as drivers do, but their degree of dependence on air quality at Hanley Road is higher than that of other users. Service providers may affect various natural processes at Hanley Road in various ways, depending on the type of service that they provide, so their general degree of interdependence with natural processes at Hanley Road is assessed as relatively low (compared with residents) although it is variable.

The next paragraph will further investigate possible interdependencies at Hanley Road by exploring the principle of purposefulness.

20.1.2 Purposefulness within Hanley Road

The idea of purposefulness in the context of the built environment refers to the correlation between functional behavioural processes and contextual natural processes.
In the context of Hanley Road, some users' activities can be differentiated and their existing correlations with natural processes explored. Rather than differentiating between the different types of users, as has been done in the previous paragraph, the differentiation done here is between the types of activities taking place at Hanley Road, regardless of who performs them. This enables a focus on the activity itself and the type of design that may support a correlation with various natural processes.
The following table is an initial attempt to examine the existing correlations between some functional activities taking place at Hanley Road and natural processes. These are again suggestive and not definitive. The chosen activities represent typical activities that take place in a dwelling as well as more general activities that take place on the street level at Hanley Road, such as: walking, cycling, driving and parking.

-	Indicates no apparent correlations
+	Indicates a low degree of correlation
++	Indicates a medium degree of correlation
+++	Indicates a high degree of correlation

Natural processes / Users' activities	Soil	Water	Sun/energy	Air/wind	Fauna	Flora
Walking	–	–	+	+	–	+
Cycling	–	–	+	+	–	+
Driving	–	–	–	++	–	–
Parking	–	–	–	–	–	+
Washing	–	+++	–	–	–	–
Toilet	–	++	–	+	–	–
Eating	–	–	–	–	–	–
Cooking	–	+	+	+	–	–
Sleeping	–	–	+	+	–	–
Playing	–	–	+	+	+	–

Table no.17 – Existing correlations between users' activities and natural processes in Hanley Road

The above table illustrates how few correlations currently exist between various functional activities and natural processes at Hanley Road, and when they do exist it is mainly at a low level of correlation. Some activities can be easily correlated with more natural processes by appropriate design. For example, eating and cooking can correlate with flora and fauna by providing spaces for residents to grow their own food. Toilet facilities can be correlated with soil. Playing can be correlated with soil and water by designing possibilities for children to engage with these processes within and outside their dwelling units.

Designing the built environment in a way that can expand and enhance these correlations will potentially contribute to the overall autopoiesis of the environment, by linking everyday functional human activities with a larger variety of natural processes. The idea of autopoiesis and its implications for the design of Hanley Road will be discussed next.

20.1.3 Autopoiesis within Hanley Road

Autopoiesis (self-creation) in the context of the built environment refers to the correlation between human autopoietic mechanisms and nature's autopoietic mechanisms, supported by the design of the environment. The idea behind autopoiesis is the attempt to look at processes in relation to one another rather than in isolation, so that the interrelationships between them can generate an autopoietic system, i.e. a system that can generate and recreate its own composing processes instead of relying on external sources/processes. Therefore, looking for opportunities to integrate human activities with natural processes is an essential step in making our environments autopoiesis, and this can be supported by design. The attempt to correlate between human behavioural processes and natural processes, through design, is essentially an attempt to design an environment that can sustain itself through various combinations and interrelations between the two different types of processes (natural and behavioural). The following table is an attempt to illustrate several possibilities for generating interrelations between behavioural activities and natural processes taking place at Hanley Road, in a way that can promote environmental autopoiesis.

Activity	Natural process(es)	Possible Interrelations
Walking	Energy	The energy released when walking can be stored in surfaces such as sidewalks and converted into electricity to power street lights and electric cars at parking spaces.
Cycling	Energy	Energy released when cycling can be stored in bicycles and converted into electricity that can be used to power other personal devices (such as ipods and mobile phones).
Driving	Soil, water	Road surfaces can be designed as porous surfaces so that rainwater can return to the soil instead of being drained off.
Parking	Energy	Parking places can be utilised as "power stations" where electric cars can be recharged.
Washing	Water	Grey water recycling systems and rainwater harvesting systems can be integrated into buildings.
Toilet	Soil, water, flora, fauna	Incorporating composting toilets and other waste treatment devices into buildings, so that faeces can be utilised as fertilisers.
Eating	Soil, fauna, flora	Designating spaces for individual and/or collective food growing and production. Incorporating individual and collective recycling facilities to recycle all food remains and packaging.
Cooking	Soil, fauna, flora	
Sleeping	Water, flora	Designing relaxed sleeping spaces that connect people to natural cycles.
Playing	Soil, water, wind, energy, flora, fauna	Revealing interrelations among various natural processes through the design of outdoor spaces as places that encourage engagement with them.

Table no.18 – Encouraging autopoiesis at Hanley Road

The above table suggests that certain activities can be related with certain natural processes, but that not all activities can correlate with *all* natural processes. By enhancing certain possibilities for correlations between human daily activities and natural processes, autopoiesis of the environment can be enhanced accordingly. For instance, converting pedestrian walking energy into electricity to power street lights and electric cars that park at Hanley Road enhance correlations between the activity of walking and the activity of driving/parking and reduce the need to use fossil fuels. Pedestrians can therefore contribute not only to their individual well-being through physical activity, but also to the wider well-being of their environment.

It should be noted that while some interrelations between activities and natural processes can be encouraged by the incorporation of technical devices and the design of the built system itself, other interrelations require redesign of the social system. For example, encouraging correlation between cooking and natural processes may only become possible through collective food-growing facilities. The differences between these two types of design (technical and social) will be further discussed in the following paragraphs.

20.1.4 Conclusions - Part/whole relation

The part-whole relation at Hanley Road refers to the relation between the users of Hanley Road, the activities that they perform daily, and natural processes in that environment. How do the relations between them support overall autopoiesis (self-creation and self-maintenance) in Hanley Road?

The low level of interdependencies between users and natural processes at Hanley Road suggest that very few possibilities currently exist for interactions between users and nature. This is reinforced by the low correspondence between different types of activities taking place at Hanley Road and natural processes. The implications of these low levels of interdependencies and purposeful correspondences between users' activities and natural processes suggest that autopoiesis of the environment at Hanley Road, which is composed of natural processes and users' activities, is almost non-existent. In order to promote autopoiesis of Hanley Road more possibilities for correspondences between users' activities and natural processes should be designed by linking natural processes with one another and with users' activities. These may include linking private activities (such as washing, going to the toilet, eating, sleeping, etc.) with natural processes, as well as linking public activities in the street domain with natural processes (such as walking and driving), and then looking for possibilities to link the private domain with the public domain, so that all natural processes are connected to one another.

The fact that negative correlations between users and natural processes currently exist at Hanley Road does not make the analysis brought forward in this section redundant. On the other hand, these negative correlations can be interpreted as a positive signal that changes can be made by designing more possibilities for positive correlations.

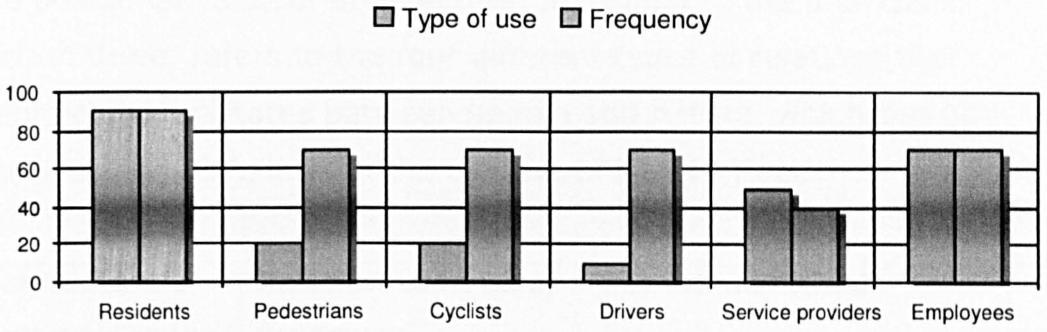
20.2 Relational Dynamics within Hanley Road

The relational dynamics between people and nature, within the context of the built environment, refer to the regulation of feedback between behavioural and natural processes, in a way that supports overall homeostasis within the environment.
In the context of Hanley Road, the different positional values of its users, and the way in which they engage or are likely to engage with natural processes in this context, will be explored and revealed.
The three ecological principles that help define relational dynamics - (1)Positional value, (2)Feedback, and (3)Homeostasis will be used respectively as stages in the analysis.

20.2.1 Positional value within Hanley Road

The idea of positional value within the context of the built environment, according to the analysis in section three, refers to: (a)users' positional value - determined by the frequency and type of use, and (b)architecture's positional value - determined by the type of relation that it facilitates between users and nature.
In the context of Hanley Road, the positional values of its users can be distinguished according to the type and frequency of use, as illustrated in the following graph and table. The graph visually illustrates the information that is given in the table. The numbers are used solely to represent different usage levels (relating to type and frequency) and therefore do not represent any measured values, but only estimated usage levels, as follows:

90 - very high	40 - medium
70 - high	20 - low
50 - high to medium	10 - very low



Graph+Table no.19 – Users' positional values within Hanley Road, mapped according to the type and frequency of use.

User	**Frequency of use**	**Type of use**
Residents	Very high (daily)	Very high (continuous and significant)
Pedestrians	High (daily)	Low (fleeting)
Cyclists	High (daily)	Low (fleeting)
Drivers	High (daily)	Very low (very fleeting)
Service providers	Medium (weekly-monthly)	High to medium (significant)
Employees (in clinics, bar)	High (daily)	High (continuous)

The above graph and table illustrate that the users with the highest estimated positional value in Hanley Road are: (1)Residents, (2)Employees, and, to some extent - (3)Service providers. The other users, such as pedestrians, cyclists and drivers have relatively low positional values in Hanley Road.

The positional value of architecture, according to the analysis in section three, refers to the four different types of relations that architecture facilitates between people and nature, which can be distinguished as follows in the context of Hanley Road:

Architecture's positional value	**Relation to natural processes**	**In Hanley Road**
Mediated - Hermeneutics	Representational understanding	None
Mediated- Embodiment	Direct, personal experience	-Front and back gardens -Regulation of energy in poorly insulated old houses
Alterity	Generic understanding	None
Background	Continuous experience (of a process) which is likely to be shared	-Trees -Front gardens -Street-Road proportions

Table no.20 – Architecture's positional value within Hanley Road

The above table illustrates the role of the built environment in connecting people to natural processes at Hanley Road. The apparent existing relations seem to be evident mainly through:
(a)Mediated-embodiment relations – which are evident in people's opportunity to attend to their front and back gardens, as well as in the need to regulate energy levels within houses, which tends to be higher in these old Victorian houses than in better insulated houses.
(b)Background relations – are evident in the street domain, in the affluence of trees and front gardens, which together with the wide street-road proportions form a relatively pleasant, well-regulated environment in terms of air quality and sun/energy.

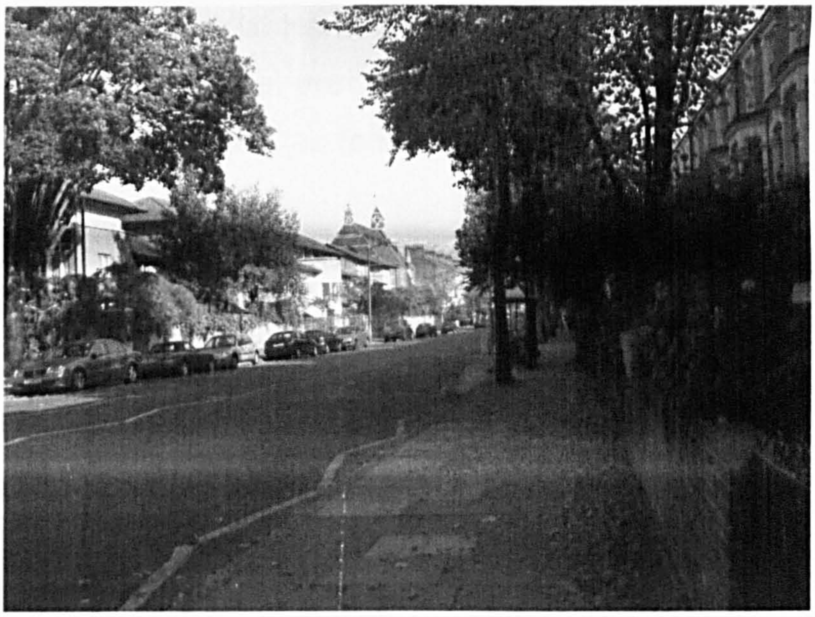


Image 17 - Street-Road proportions at Hanley Road

It becomes evident that there is still plenty of untapped potential in connecting people to natural processes, through the built environment, within the context of Hanley Road.
The next paragraph will examine what kind of feedback relations exist between specific users of Hanley Road and natural processes, and what kind of feedback relations architecture can support between users and natural processes at Hanley Road.

20.2.2 Feedback mechanisms within Hanley Road

The idea of feedback within the context of the built environment refers to the possibilities of regulating behavioural processes in relation to natural processes within the environment. The different positional values of users and architecture in relation to natural processes can help in introducing feedback mechanisms, which are appropriate within a specific context.

In the context of Hanley Road, existing feedback relations between users and natural processes can be examined, according to their positional values, as follows:

User	**Positional value**	**Feedback with natural processes**
Residents	Very high	-Maintenance of front and back gardens -Adjustment of heat/energy levels indoors
Employees (clinics, bar)	High	None
Service providers	Medium	-Trees maintenance
Pedestrians	Low	-Influenced by trees and front gardens
Cyclists	Low	-Influenced by trees and front gardens
Drivers	Low	-Influence on air quality

Table no.21 – Users' feedback relations with natural processes at Hanley Road

The above table illustrates that there is, to a degree, a lack of correlation between users' positional value and their existing feedback relations with natural processes at Hanley Road. Residents, who possess the highest positional value in Hanley Road, have very limited possibilities for feedback relations with natural processes, some of which are a consequence of poor insulation, and some of which can take place only in the context of their private or semi-public gardens (which may be limited only to ground floor residents). Most of these gardens at Hanley Road are not well maintained, so even this potential for feedback is hardly utilised. Other employees who work in Hanley Road, and also possess a relatively high positional value, have no possibilities for feedback relations with natural processes. It therefore becomes apparent from the above table that there is a lot of potential to design more possibilities for feedback relations between the different types of users who occupy Hanley Road and natural processes (especially residents and employees).

The possibilities for introducing feedback relations between people and nature, within the context of the built environment, can be mapped according to the different positional values of architecture. The following table illustrates the variety of these existing and potential possibilities in the context of Hanley Road.

Natural process	**Architecture's positional value**			
	Mediated-hermeneutics *(this type of relation is achieved by incorporating technological gauges into the built system that reveal contextual natural conditions).*	***Mediated – embodiment*** *(this type of relation is achieved through design solutions that directly compliment existing natural processes to result in their enhancement).*	***Alterity*** *(this type of relation is achieved by incorporating technological systems into the built environment that can inform users about generic natural processes).*	***Background*** *(this type of relation is achieved by integrating seemingly isolated natural processes with one another through the design of the built infrastructure).*
Soil	A gauge to reveal soil conditions near each building.	Possibilities for enriching the soil currently exist to some extent through the gardens. More possibilities can be created through the incorporation of composting toilets and waste management	An interactive system that gives information about different types of local soil at Hanley Road (can be incorporated into public areas such as bus stations).	Exposing the soil at Hanley Road through the design of porous road and sidewalk surfaces such that water can return to the soil.

		facilities into buildings.		
Air/ wind	A gauge to reveal current air/ wind conditions at several strategic points along the street.	Incorporating better design solutions for natural ventilation and passive cooling as well as better insulation in winter.	An interactive system that gives general information about wind currents/ air pollutants at Hanley Road.	Air pollutants are counterbalanced by the affluence of trees at Hanley Road. Encouraging use of electric cars by providing recharge stations for them can also reduce pollution.
Sun/ energy	A gauge to reveal heat/ energy levels inside every building.	Designing for passive solar gain. Incorporating solar collectors, geothermal heat pumps and other types of energy efficiency devices.	An interactive system that gives information about energy usage patterns at Hanley Road.	Converting available energy into electricity on the urban level (i.e. the utilisation of pedestrian movement, wind and solar power).
Water	A gauge to reveal water conditions in every building.	Incorporating rainwater harvesting and grey water recycling systems, and generally making hydrological processes visible through design.	An interactive system that gives information about local hydrological cycles and water usage patterns at Hanley Road.	Connecting private water systems with public ones and exposing them to view. Incorporating water-purifying systems such as reed-beds where necessary.
Flora	A gauge to reveal flora conditions at several points along the street.	Incorporating green roofs/walls and utilising gardens to a greater extent.	An interactive system that gives information about local types of flora at Hanley Road.	Connecting back and front gardens to one another and linking them with trees on sidewalks.
Fauna	A gauge to	Incorporating	An interactive	Generating 'wild-

	reveal fauna conditions at one point along the street.	green roofs/walls and utilising gardens to a greater extent.	system that gives information about local types of fauna at Hanley Road.	life corridors' by linking flora and fauna areas.

Table no. 22 – Architecture's role in introducing feedback relations at Hanley Road

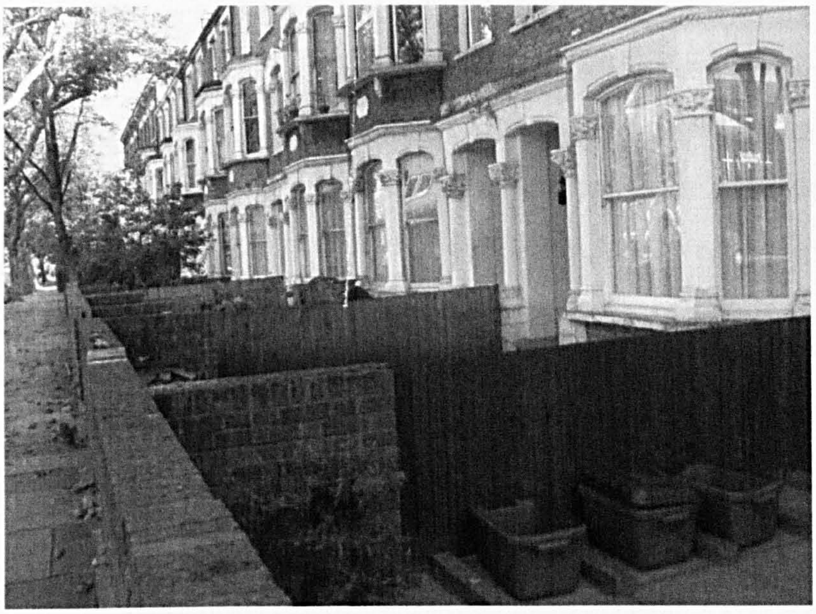


Image 18 – Separated front "gardens" in Hanley Road, which can be better utilised and linked to one another.

The above table exemplifies the different types of possibilities that architecture can provide in introducing feedback relations between people and natural processes in the context of Hanley Road.
The following paragraph will explore whether feedback relations in Hanley Road support homeostasis in the environment.

20.2.3 Homeostasis within Hanley Road

The principle of homeostasis within the context of the built environment refers to the introduction of negative feedback mechanisms (i.e. feedback that is introduced in order to counteract disturbances) in order to regulate behavioural processes and natural processes in relation to one another, in a way that promotes overall environmental homeostasis.

In the context of Hanley Road, environmental homeostasis is currently achieved mainly by the involvement of service providers and council workers, who take care of: waste collection, tree-cutting, water, gas, electricity supplies, communication networks, etc. Some services (mostly public ones) are provided by the local council; while other services (mostly private ones) are provided to individual households by various service providers. The lack of correlation between the various service providers means that each household is responsible for its own services, and so regulation is restricted to individual households; while responsibility for homeostasis within the entire street lies with the local council and not with the residents themselves.

Promoting personal responsibility for collective environmental homeostasis within Hanley Road should, therefore, begin by linking individual responsibility with public responsibility by creating direct links between private services and public services. For example, all service provided to households, such as: gas, electricity, water, communication networks, waste collection, etc. can become interconnected on a neighbourhood level. This would encourage personal responsibility for these services on an individual-household level, as well as on a collective level - since a disruption to a service on an individual level would immediately become apparent on the collective level as well.

The principle of homeostasis illustrates the implications of the ecological approach not only on the building design/technological level but also on a wider social organisational design level. The ability to reach environmental homeostasis over the long run is dependent upon the regulation of various environmental as well as behavioural processes, and it cannot be achieved solely through the redesign of the built system. It must incorporate the redesign of human behaviour on a social level, in a way that integrates and coordinates human actions and sustainable technological solutions with natural processes.

Image 19 – Recycling bins in Hanley Road. Responsibility for recycling collection lies with the local council. Therefore, residents have no method for regulating homeostasis in their environment by encouraging collective responsibility for recycling.

20.2.4 Conclusions – Relational dynamics

The relational dynamics at Hanley Road refer to the dynamics between the users of Hanley Road and natural processes, and how these dynamics constitute overall homeostasis within Hanley Road. The differentiation between the various positional values of Hanley Road's users revealed that residents have the highest positional value, followed by employees and service providers. It has been shown that these positional values don't correspond to the degree of feedback relations that is currently evident between these users and natural processes. In fact, service providers seem to have the highest possibilities for regulating feedback relations with natural processes at Hanley Road. This lack of correlation between positional values and feedback relations at Hanley Road means that the people who actually use the environment the most (i.e. residents) are not involved in its ongoing maintenance and regulation. In other words, the responsibility for the environment is "imported" to 'external' service providers, instead of being regulated by its own users. There is a lot of untapped potential to design further possibilities for feedback between Hanley Road's users and natural processes, such as those expressed in table no. 22 (pp.247-9). These feedback possibilities can be utilised accordingly by the users with the highest positional values at Hanley Road, who will be able to contribute to the ongoing regulation of homeostasis in their environment.

20.3 Emergence within Hanley Road

The phenomenon of emergence, within the context of the built environment, refers to the formation of new organisational levels within the environment over time, which may result from new connections between apparently unrelated systems and processes. In the context of Hanley Road, the possibilities for generating emergence in the environment will be explored and revealed. The three ecological principles that help define emergence– (1)Holarchy, (2) Increasing complexity, and (3) Self-transcendence will be used respectively as stages in the analysis.

20.3.1 Holarchic organisation within Hanley Road

The idea of holarchy, within the context of the built environment, refers to the design of platforms that encourage unanticipated interactions between people and natural processes. The introduction of positive feedback (i.e. feedback that is introduced to reinforce an existing process or disturbance) can accelerate the process by connecting apparently unrelated systems in a way that enhances contextual self-regulation and evolution. In the context of Hanley Road, current development processes of new and refurbished flats seem to be pointing in the opposite direction. Instead of encouraging more interactions and connections between natural processes and behavioural processes, developers tend to block existing opportunities for interactions with natural processes in order to gain additional floor space. Therefore, existing front gardens are abandoned for the sake of improved access to new basement flats. This not only disrupts the existing urban fabric, but also eliminates one of the few relations to nature that currently exist in the street domain.

Image 20 – Front gardens give way to private new access to refurbished basement flats

Introducing positive feedback in this instance could entail reinforcing the existing tendency for refurbishments and new developments at Hanley Road by utilising them as opportunities to establish new links between various environmental and social processes. Improved access and new entrances to flats can be considered as a positive development since they provide increased privacy as well as additional possibilities for generating new connections between the private and the public domain. Instead of looking to block opportunities for a private/public connection with an erection of a wall (as is the case in the photo above), private/public links can be encouraged through appropriate design. One example may be the incorporation of various composting and recycling facilities (of waste, water, etc.) into the street-facing façade in such a way that makes evident which household recycles and which does not, and links the private recycling systems with one another. This can encourage not only increased responsibility for recycling among the residents, but also increased awareness to these processes among pedestrians, cyclists and visitors who become exposed to them on the street level. This type of design solution can be considered as 'positive feedback' in the context of Hanley Road since it reinforces not only the proliferation of new developments but also the proliferation of environmental responsibility and awareness in Hanley Road on both the private and public domains.

In this way, the loss of the front garden can be compensated for by the addition of new (and improved) connections between the house and the street and between various local natural and social processes.

Holarchy implies a possibility to generate new, unanticipated environmental connections, which slowly lead to a (bottom-up generated) change in the built environment. The ability to assess holarchy is exemplified through the next principle of increasing complexity.

Image 21 – Front gardens provide a connection between the private and public domains in Hanley Road, and can therefore become a focal point for expressing such links in relation to wider environmental/social processes.

20.3.2 Increasing complexity within Hanley Road

The principle of increasing complexity, within the context of the built environment, refers to an increased connectivity between natural processes, people's actions and the built system, and increased distinction between the various architectural systems, over time.

In the context of Hanley Road, increased connectivity between natural processes, people's actions and the built system is *not* apparent throughout the development of the street. If any, there is a decreased connectivity between the three processes, as has been mentioned in the previous paragraph with the example of the elimination of the front gardens in new developments. However, increased distinction is apparent, to some extent, in newer forms of buildings that have been built in the street over the years.

Image 22 - A mid-century building type in Hanley Road, which does not correspond to the conventional Victorian terraced-houses within the street

However, these newer additions to Hanley Road do not exemplify an overall environmental "increase in complexity," which implies that the increase in distinction of architectural systems usually arises as a result of an increase in connectivity between the differentiated processes that they embody (natural, behavioural and built processes). Moreover, the new buildings do not contribute to an increase in complexity of the urban structure as a whole, by adding new levels to it or enabling new activities to take place within it; instead, they tend to disrupt the already existing urban fabric without adding any new dimensions to it.

The newer building additions to Hanley Road therefore tend to exemplify a decrease in complexity, since they reduce rather than enhance the possible connections between the built system, people, and natural processes. An 'increase in complexity' within Hanley Road will become possible if new developments are encouraged to strengthen existing connections between its users, their daily activities, the built system itself and natural processes.

20.3.3 Self-transcendence within Hanley Road

The idea of self-transcendence, within the context of the built environment, refers to the way in which a built system transcends its own organisation to result in a new type of system. Self-transcendence can occur as a result of: (1)heterogeneous cooperation, which integrates built systems with natural and behavioural processes; and (2)homogeneous cooperation, which is the duplication and differentiation of one architectural system.

In the context of Hanley Road, self-transcendence is not evidently apparent, but there is potential to generate it to a certain extent. The fact that urban continuity exists in the form of the terraced-house means that some aspects of this already existing continuity can be utilised to generate homogeneous cooperation, which integrates natural processes into the built system (i.e. one architectural type can be duplicated and differentiated in the entire street to generate a new urban pattern which incorporates natural processes into it).

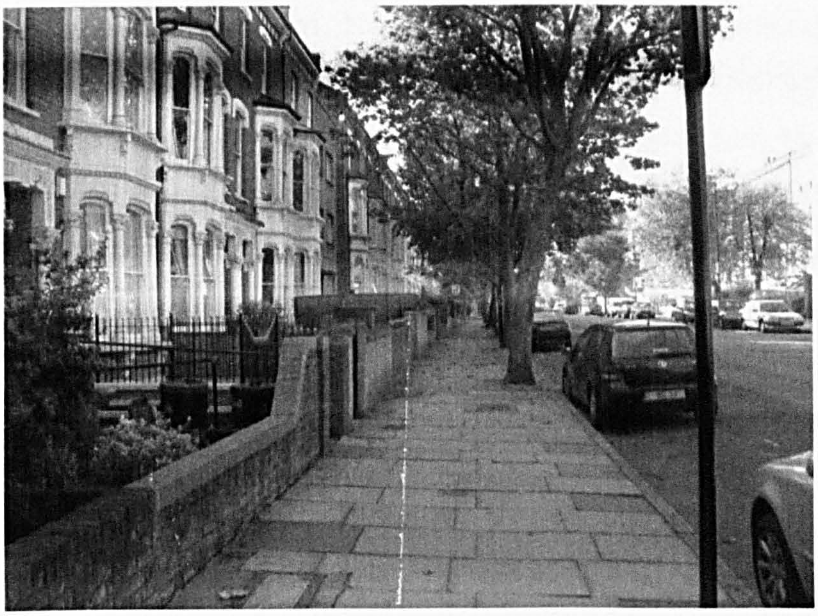


Image 23 - Continuity of urban form within Hanley Road apparent through the terraced-houses

The homogeneity of the urban form in Hanley Road can therefore become a 'trigger' for self-transcendence through homogeneous cooperation. For example, a refurbishment project at Hanley Road, which incorporates new recycling facilities at street façade, can provide a precedent for similar future developments. This kind of urban development can be considered as homogeneous self-transcendence since it enables the emergence of a new urban pattern through its duplication and differentiation to suit individual household requirements (e.g. some households may incorporate water recycling systems as well as waste recycling while others may not, etc.).

On the other hand, self-transcendence through heterogeneous cooperation may prove to be more difficult to achieve in a context such as Hanley Road, where the terraced-house continuity can restrict certain types of developments which are more bold and unusual and do not conform to the urban form.

Heterogeneous cooperation is not currently evident within Hanley Road, but can be similarly encouraged, at least to an extent, by the redesign of certain existing systems and the incorporation of natural processes into them. New developments and refurbishments currently taking place at Hanley Road can encourage the incorporation of systems and processes that aim to generate new connections between activities taking place within the household and natural processes in the wider environment. This can encourage, over the long run, self-transcendence within Hanley Road, as new developments open possibilities for new connections to be made between the private and public domains at Hanley Road, in a way that incorporates natural processes and encourages users' sustainable behaviour.

20.3.4 Conclusions – Emergence

Emergence within Hanley Road refers to the possible generation of new, unanticipated situations within the built environment, which result from interactions between users, natural processes and the built system. Emergence is not currently evident within Hanley Road. The newer built additions to Hanley Road point to a decrease in the complexity of the environment, which entails that less connections and links are apparent between users and natural processes. Although emergence is not currently evident within Hanley Road, it can be encouraged, over the long run.
In order to encourage emergence in Hanley Road, new developments and initiatives should open further connections between existing natural processes at Hanley Road (e.g. by connecting hydrological processes with the soil, etc.), as well as enabling new connections between users and natural processes, in such a way that may lead to an increase in the overall complexity of the environment. These should include connections between residents and natural processes at the private domain, as well as connections between other users and natural processes at the public domain. Once these new connections are enabled, as part of the environment, by utilising existing platforms, emergent relations may begin to become manifest in Hanley Road, over time.

20.4 General conclusions from Section Four

Applying the ecological principles to a case study revealed that these principles are useful for illuminating existing relations within a specific context, as follows:

1. The principles that explore the part/whole relation (interdependence, purposefulness and autopoiesis) help to illuminate some basic correspondences (or the lack of them) between the various processes examined and their relation to the whole (in this case, the whole was defined as the natural environment/natural processes, while the parts referred to the various behavioural processes/types of users).
2. The principles that explore the relational dynamics (positional value, feedback and homeostasis) help to illuminate the actual interrelations that exist, or could exist, between the various processes and the whole, and where they might be improved to generate better overall homeostasis.
3. The principles that explore the phenomena of emergence (holarchy, increasing complexity and self-transcendence) help to illuminate whether new organisational levels are apparent over time, and if not, how they may be encouraged.

Examining Hanley Road in terms of the existing relations between its users and natural processes revealed that these relations do not support an 'ecological' environment, i.e. that there is no correlation in purposes between behavioural and natural processes, nor correlation between users' positional values and the feedback relations that take place in that environment. The lack of correlations entails that no emergence or development is possible between people and natural processes, as part of the built environment. By learning to utilise existing platforms at Hanley Road (front gardens are one major platform), which can support and strengthen ecological relations between users and natural processes, further growth and development of this environment can be enabled.

The method of analysis brought forward in this section, according to the ecological principles described above, proved useful in revealing existing positive as well as negative correlations in the environment. The existence of negative correlations does not imply that the method of analysis or the ecological principles chosen are redundant. On the contrary, it proves that the approach taken in this analysis has been successful because:
(a) it can accommodate both positive and negative correlations
(b) it provides a framework for their simultaneous evaluation, and most importantly;
(c) it opens possibilities for positive solutions that can enhance the ecological performance of an environment, by accommodating a variety of processes next to one another, without compromising any of them.

The main drawback of the analysis method brought forward in this section is that it is complex, and for this reason it had to be narrowed down to examine only relations between *natural* and *behavioural* processes, within an existing context, and on a relatively small scale. Whether or not the same analysis method can be applied to more complex projects, which take under consideration a wider variety of processes (such as: environmental, social, cultural, economical, political, and others) remain to be proven.
It is also suggested that the same analysis method can be applied to anticipated projects (i.e. at the design stage) rather than used solely for the improvement of already existing contexts.

21. General Conclusions from Thesis

The aim of this thesis has been to investigate whether an understanding of ecological principles can inform sustainable architecture and if so, then in what ways.

It has been suggested that the ecological principles, applied to the built environment, can inform existing relations between people ('the users') and natural processes on site, by viewing the architectural environment as an interface between the two processes (i.e. the behavioural and the natural). In this way, the focus of architecture may shift from an occupation with the architectural object alone, into a wider investigation of the possible relations that it enables between its users and natural processes. This perspective may be able to open up new ways of perceiving and assessing the role of sustainable architecture, by using the ecological principles brought forward in this thesis as guidelines for manifesting ecological relations between people and natural processes within the context of the built environment.

The following table is an attempt to summarise the contribution of each ecological principle to the assessment of ecological relations in the context of architecture, as it has been investigated in this thesis.

Ecological Principles		Architecture
I. Part/ Whole	*1. Interdependence*	What interdependencies exist between people and natural processes on site?
	2. Purposefulness	What correlations in purpose exist between behavioural and natural processes on site?
	3. Autopoiesis	How can autopoiesis of the overall environment be enhanced by correlating autopoiesis of natural processes with autopoiesis of behavioural processes?
II. Relational Dynamics	*4. Positional value*	Assessing different positional values of users and different positional values of architecture in relation to natural processes on site
	5. Feedback	Revealing existing and potential feedback relations between different types of users and natural processes according to their positional values, as well as existing and potential feedback relations between architecture and natural processes on site
	6. Homeostasis	How can overall homeostasis be encouraged in the environment through the introduction of negative feedback?
III. Emergence	*7. Holarchic organisation*	How can holarchy be encouraged in the environment by creating platforms for unanticipated interactions between people and natural processes, and by the introduction of positive feedback?
	8. Increasing complexity	Is increasing complexity apparent in the environment through increased connectivity between behavioural, natural and built processes, and through increased distinction between the various architectural systems?
	9. Self-transcendence	Is self-transcendence apparent in the environment through heterogeneous (integration of behavioural, natural and built processes) or homogeneous (duplication and differentiation) cooperation?

Table no. 23 - The contribution of ecological principles to the assessment of ecological relations within the context of architecture.

The above table exemplifies how an assessment of ecological relations between people and nature, within the context of the built environment, may be carried out through an understanding of ecological principles. This assessment is the result of a research process carried out in this thesis, which is summarised in the conclusions below.

1. The first section of the thesis, which introduced the ecological principles of organisation in living systems, revealed how living systems are able to develop and become more complex over time, through the cooperative interactions between them. The relevance of these principles to architecture is in shifting the focus of design from designing objects to designing relationships and processes, by giving primary consideration to the existing and potential relations between people and natural processes and enabling them to take place on site through the design of the built environment. In this way, the broader implications of design will be automatically considered by enlarging the focus of reference from a specific object to the relations that constitute its existence within a specific context.

2. The second section of this thesis revealed several contradictory discussions within the sustainable design discourse in relation to nature, the user and technology:

- The relation to nature, within sustainable design, ranges from a relation that stems from fear to a relation of responsibility, and all the way to a general tendency to draw inspiration from nature in various ways. A general underlying tendency common to the various perspectives is a preservation of the current nature-culture distinction, through a suggestive detached relation to nature, which generally does not promote human experiential inherence in natural processes.

• The relation to 'the user' within sustainable design discourse ranges from viewing the user as an obstacle for achieving sustainability to integrating user requirements into design considerations as a very basic constituent, and all the way to user-participative approaches which involve users in a project from a very initial design stage. These often contradicting approaches to the user within sustainable design discourse point to a need to re-evaluate the basic values of sustainability in relation to people's involvement and responsibility for the environment they engage with.

• The affinity to technology is manifested within sustainable design discourse in the tendency to approach environmental problems from a ratio-technological perspective, which is apparent in the application of various linear methodologies to solve sustainability issues. Under this type of framework, sustainable products and systems tend to become extra fuel for generating yet additional consumerism patterns within the existing ratio-technological system.

It has therefore been concluded from the second section that an ecological understanding of living systems may be able to bridge the current existing gaps within the sustainable design discourse by offering a holistic and comprehensive view on complex living systems and the ways in which they are sustained and developed by their composing agents/processes over time.

3. The third section attempted to apply the ecological principles that were introduced in section one into architecture, by defining the built environment as a platform for manifesting ecological relations between people and natural processes on site. Each of the chosen nine ecological principles was discussed, in turn, regarding its possible interpretation within the context of the built environment.

The nature of the argument in this section was therefore speculative and suggestive, which enabled a possibility to explore architecture as a potential platform for dynamic, ecological relations between behavioural and natural processes, and not as a static and pre-determined object.

The conclusions from this section suggest that architecture does have the potential to manifest at least some of the ecological principles, by designing opportunities, as part of the built environment, for people to constantly interact with natural processes, and to be able to regulate their behaviour in relation to these natural processes, such that everyday human actions and natural processes become part of the regulation of the built environment itself. In other words, making the built environment 'ecological' entails integrating the processes that constitute its on-going maintenance into one autopoietic system that can regulate itself.

The degree to which an architectural environment can become ecological is dependent on the degree to which the relations between its composing processes become manifest and develop over time. Since people ('the users') constitute one essential process of an ecological architectural environment, the responsibility for making that environment ecological, over the long run, lies partially in the hands of its users. The implications for design are in shifting the focus away from designing finished objects into creating the **potential** for an ecological architecture, by designing **possibilities for relations** between people and natural processes. Therefore, architecture can be viewed as an ongoing process where part of the responsibility for maintaining these relations and making them apparent in the environment over time is the responsibility of each user in his/her everyday interactions with the surrounding.

Some ecological-architectural systems may 'evolve' over time to generate new, 'higher' organisational levels within the built environment, which may be manifested on an urban level; while other ecological-architectural systems may not evolve as such. The ecological process of holarchic evolution within design, as well as within the natural world, cannot be entirely anticipated in advance, but it can and should be aimed at producing mutually enhancing relationships between its composing processes.

4. The forth section of the thesis, which included the analysis of 'Hanley Road' - a case study, exemplified how the ecological principles may be interpreted within an existing context. The case study provided an opportunity to observe how the ecological principles overlap and influence the "performance" of one another. For example, the minor degree of interdependence between natural and behavioural processes at Hanley Road meant that it was difficult to recognise correlation in purposes, which in turn meant that autopoiesis was non-existent in this environment. Similarly, a lack of holarchy meant that there was no increase in complexity and no self-transcendence evident. However, the drawbacks and their circular influence on one another also entail that one simple solution may have far-reaching consequences (i.e. as in a 'positive feedback' manner). In the case of Hanley Road, strengthening the relation between the private and public domains through the integration of private and public services, and their relation with natural processes, which can be made evident on both levels and influence one another, may trigger a series of 'positive feedback' changes within the street.

21.1 Possible implications of this research

The application of the ecological principles to architectural design theory has the potential to generate several implications, some of which may include the following:

1. It can inform current notions of sustainable design theory by suggesting that an 'ecological design' is not merely a design solution that is better integrated with natural processes and/or with its environment, but is rather a more encompassing term for a design solution that manages to integrate the processes that constitute its ongoing maintenance into one autopoietic system that can regulate itself and develop over time.
2. In the context of the built environment, it can help to promote the design of architectural systems which take more seriously into consideration the broader and complex implications of every built project, not only in terms of its "environmental impacts", but also in terms of the set of relationships that it enables its users to have with the environment, including natural, social and built processes.
3. It can promote design solutions that enhance people's connection to their environments, by actively engaging users with their everyday surroundings, and requiring people's participation in the formation and maintenance of the built environment.
4. It can promote design solutions that enhance ecological behaviour of people, by making them more aware of their actions and the implications of their actions on the environment, as an integral part of their active engagement with natural processes (potentially on a daily basis).
5. It can potentially promote design solutions that encourage co-operation between people on various levels, as the interactions between people and the environment begins to

have higher-order consequences on neighbourhood and urban levels.

21.2 Further potential research

It is my hope that this research has managed to contribute to the field of sustainable design theory by offering a new interpretation of 'ecological design' which is based on an understanding of ecological organisation in living systems and their possible contribution to the way we may be able to view the role of architecture in the environment.

Further potential research, which can build on the suggestions brought forward in this thesis, may include the following:

1. *Applying the ecological principles to other architectural processes* - the limited scope of this research has meant that the ecological principles have been applied solely to the relations between behavioural and natural processes (which were assumed to reflect core processes within the built environment). However, it has been acknowledged that there are other relevant processes which influence the formation of architecture (such as: social, cultural, political, economical and others), and these should be acknowledged in future research[36]. Applying the ecological relational principles as an assessment method to the possible interrelations among such processes may help in understanding how they can be better integrated for mutual benefit.
2. *Applying the ecological principles to other fields* - the introduction to section one (p.24-27) listed several attempts of introducing ecological principles into various fields. However, the evaluation of ecological principles as brought forward in this thesis has the potential to provide a comprehensive framework for their application as an *organisational unity* into other design fields. One example is

[36] Research into the influence of various processes on the formation of architecture is already evident, see for example: *Ujam, F. (1999) Locus architecture* on cultural and ecological processes in architecture.

the current application of these ecological principles into the emerging field of *Metadesign*[37] which attempts to provide a platform for the collaboration of designers from various fields.

3. *Adopting the ecological principles framework to suit different types of built project* – the case study presented in the fourth section of this thesis ('Hanley Road') provided an example of how the ecological principles may be applied within a specific urban context. It is assumed that different types of projects, with differing complexity levels, may require slightly different adaptations of the ecological principles to correspond to existing and/or relevant contextual processes. Also, using the ecological principles framework as a *pre-* or *post-*occupancy assessment method to investigate either *existing* or *probable* relations between users and the processes they interact with may prove to constitute a slightly different process, which requires further investigation.

[37] See *Dinur, B., Wood, J. (2008). Using ecological principles to benchmark design synergies.*

22. Bibliography

Abley, I., Heartfield, J., Ed. (2001). *Sustaining architecture in the anti-machine age.* Sussex: Wiley-academy.

Abram, D. (1996). *The spell of the sensuous.* New-York: Pantheon books.

Ackoff, R. (1971). "Towards a system of systems concept." *Management Science* **17**(11): 661-671.

Alexander, C. (1979). *The timeless way of building*. New-York: Oxford University Press.

Alexander, C., Ishikawa, S., Silverstein, M. (1977). *A pattern language*. New-York: Oxford University Press.

Alexander, C. (2002). *The Nature of Order.* Berkeley: The center for environmental structure.

Anker, P. (2005). "The closed world of ecological architecture." *The journal of architecture* **10**(5): 527-552.

Arthur, B. (1999). "Complexity and The Economy." *Science* **April**(284): 107-109.

Baker, N. V., Standeven, M. A. (1995). "A behavioural approach to thermal comfort assessment in naturally ventilated buildings." *Proceedings of CIBSE National Conference*, Eastbourne: International Energy Agency, 76-84.

Barabasi, A. L. (2002). *Linked: The new science of networks.* Cambridge, MA: Perseus Publishing.

Bateson, G. (1979). *Mind and Nature: A necessary unity*. New Jersey: Hampton Press.

Bauman, Z. (1998). *Globalization: The human consequences.* Cambridge: Polity Press.

Bech-Danielsen, C. (2003). "Ecological reflections in unbounded architecture." *The journal of architecture* **8**(Autumn): 321-336.

Becker, C. (2006). "The human actor in Ecological Economics." *Ecological Economics* **60**(1): 17-23.

Ben-dov, Y. (2000). "The web image: organic, mechanic and digital." http://bendov.info/eng/webimage.htm. [accessed July 2003].

Bennett, J. (2004). "The force of things: steps toward an Ecology of Matter." *Political Theory* **32**(3): 347-372.

Bergson, H. (1912). *An introduction to Metaphysics.* Indianapolis: Hackett Publishing company.

Blundell Jones, P. (2005). "Ozcul postscript: the Gelsenkirchen school as built." in Blundell Jones, P., Petrescu, D., Till, J. (eds). *Architecture and participation.* London: Spon Press: 173-180.

Blundell Jones, P., Petrescu, D., Till, J., (eds). (2005). *Architecture and participation.* London: Spon Press.

Bohm, D. (1995). *Wholeness and the implicate order.* New-York: Routledge.

Bossel, H. (1998). *Earth at a crossroads.* Cambridge: Cambridge University Press.

Brand, S. (1994). *How buildings learn.* London: Viking publishing.

Brennan, A., Yeuk-Sze Lo. (2008). "Environmental Ethics." *The Stanford encyclopedia of philosophy* (Spring 2008 edition). Zalta, N. E.(ed). URL= <http://plato.stanford.edu/archives/spr2008/entries/ethics-environmental/>

Brundtland, G. (1987). "Our Common Future: The World Commission on Environment and Development." Report no. 42/187. Oxford: Oxford University Press.

Capra, F. (1982). *The turning point.* London: Flamingo.

Capra, F. (1997). *The web of life.* London: Flamingo.

Carlo, D. G. (1970). "Architecture's public." in Blundell Jones,P., Petrescu, D., Till, J. (eds). *Architecture and Participation.* London: Spon Press: 3-22.

Carson, R. (1962). *Silent spring* (2002 edition). Boston: Mariner Books.

Charlick, P., Nicholson, N. (2001). "Ecological frequencies and hybrid natures." *Sustaining architecture in the anti-machine age*. Abley, I., Heartfield, J. (eds). Sussex: Wiley-academy: 64-71.

Chiel, H., Beer, R. (1997). "The brain has a body: Adaptive behaviour emerges from interactions of nervous system, body, and environment." *Trends in Neurosciences* **20**: 553-557.

Coyne, R. (2005). "The Net Effect: design, the rhizome, and complex philosophy." *Proceedings of Design out of complexity workshop*, London, ECID. [http://www.casa.ucl.ac.uk/cupumecid_site/papers.htm, accessed September 2006]

Crowe, N. (1995). *Nature and the idea of a man-made world.* Massachusetts: MIT Press.

Davis, P. (1989). *The cosmic blueprint.* London: Unwin Hyman Limited.

Day, C. (2000). "Ethical building in the everyday environment." in Fox, W. (ed). *Ethics and the Built Environment.* London: Routledge: 127-138.

De Geus, M. (1999). *Ecological utopias: envisioning the sustainable society.* Utrecht: International books.

Deleuze, G., Guattari, F. (1988). *A thousand plateaus.* London: The Athlone press.

Dillon, M. C. (1988). *Merleau-Ponty's Ontology*. Indianapolis: Indiana University Press.

Dinur, B., Wood, J. (2007). "Using ecological principles to benchmark design synergies." *Presented at the Fourth International Conference for Environmental Education*. Ahmedabad, India.

Dovey, K. (1985). "The quest for authenticity and the replication of environmental meaning." in Seamon, D., Mugerauer, R. (eds). *Dwelling, place and environment*. New-York: Columbia university Press: 33-49.

Dubos, R. (1970). *Reason awake: science for man*. New-York: Columbia University Press.

Dusek, V. (2006). *Philosophy of technology: an introduction.* Oxford: Blackwell Publishing.

Eblen, R. A., Eblen, W. (1994). "Ecosystems." *The Encyclopedia of the Environment.* Boston: Houghton Mifflin Company.

Edwards, B., Turrent, D. (2000). *Sustainable housing: principles and practice.* London: E&FN spon.

Ehrlich, R. P., Ehrlich, A.H., Holdren, J.P. (1973). *Human Ecology: problems and solutions*. San-Francisco: W.H Freeman.

Farmer, J. (1996). *Green shift.* Oxford: Butterworth-Heinemann.

Forty, A. (2000). *Words and buildings: a vocabulary of modern architecture.* London: Thames & Hudson.

Gadow, S. (1992). "Existential ecology: The human/ natural world." *Soc. Sci. Med.* **35**(4): 597-602.

Gage, S. (1998). "Intelligent interactive architecture." *Architectural Design* (November): 81-85.

Gare, A. (2000). "The postmodernism of deep ecology, the deep ecology of postmodernism, and Grand Narratives." in Katz, E., Light, A., Rothenberg, D. (eds). *Beneath the surface.* London: MIT Press.

Gibson, J. J. (1979). *The Ecological approach to visual perception.* Boston: Houghton Mifflin.

Goldsmith, E. (1998). *The way: an ecological world view.* Athens: The university of Georgia Press.

Greene, B. (2000). *The elegant universe: superstrings, hidden dimensions, and the quest for the ultimate theory*. New York: Vintage.

Gutman, H. (1969). "Structure and function in living systems." in Wilson, Wilson, Whyte (eds). *Hierarchical structures.* New-York: American Elsevier.

Guy, S., Farmer, G. (2000). "Contested Constructions." in Fox, W. (ed). *Ethics and the Built Environment.* London: Routledge: 73-87.

Habraken, N. J. (2000). *The structure of the ordinary.* Cambridge: MIT Press.

Hagan, S. (2001). *Taking shape: a new contract between architecture and nature.* Massechussets: Architectural Press.

Hahn, J. (1995). "The ecological paradigm in architecture." http://home.earthlink.net/~jluke313/test_frame.html. [accessed 7 November 2003].

Hamilton, D. (1973). *Technology, man and the environment.* London: Faber and Faber ltd.

Hardin, G. (1968). "The Tragedy of the Commons." *Science*(162): 1243-1248.

Hardin, G. (2001). "Carrying capacity as an ethical concept." *The social contract* (Fall 2001): 48-57.

Hayles, K. (1996). "Narratives of artificial life." in Robertson, G., Mash, M., Tickner, L., Bird, J., Curtis, B., Putnam, T. (eds). *FutureNatural.* London: Routledge.

Hayles, K. (1997). "Liberal subjectivity imperiled: Norbert Wiener and cybernetic anxiety." www.english.ucla.edu/faculty/hayles/Wiener.htm. [accessed July 2004].

Heylighen, F. (1996). "The growth of structural and functional complexity during evolution." in Heylighen, F., Bollen, J., Riegler, A. *The evolution of complexity.* Brussles: University Press: 17-44.

Heylighen, F. (1997). "The science of self-organization and adaptivity." http://pespmc1.vub.ac.be/Papers/EOLSS-Self-Organiz.pdf. [accessed October 2004].

Heylighen, F. (1998). "Basic concepts of the systems approach." http://pespmc1.vub.ac.be/SYSAPPR.html. [accessed September 2004].

Holland, J. (1995). *Hidden Order: How adaptation builds complexity.* New York: Helix Books.

Holmgren, D. (2004). "Essence of Permaculture." http://www.holmgren.com.au/ [accessed March 2008].

Hough, M. (1995). *Cities and natural processes.* London: Routledge.

Howard, N. (2000). *Sustainable Construction: the Data.* Watford: Centre for sustainable construction, Building research establishment.

Illich, I. (1973). *Tools for conviviality.* London: Calder & Boyars.

Ingold, T. (2000). *The perception of the environment.* London: Routhledge.

Jacobs, J. (1961). *The death and life of great American cities.* New York: Random House.

Jencks, C. (1995). *The architecture of the jumping universe.* London: Academy editions.

Jencks, C. (2005). *The Iconic Building.* New York: Rizzoli.

Johnson, S. (2001). *Emergence: The connected lives of ants, brains, cities and software.* London: The Penguin Press.

Kay, J., Regier, H., Boyle, M., and Francis, G. (1999). "An ecosystem approach for sustainability: addressing the challenge of complexity." *Futures* **31**(7): 721-742.

Keiny, S. (2002). *Ecological thinking: A new approach to educational change.* New York: University Press of America.

Kellert, S. (1993). "The biological basis for human values of nature." in Kellert, S., Wilson, E. (eds). *The biophilia hypothesis.*Washington: Island Press: 42-72.

Kendall, S., Teicher, J. (2000). *Residential open buildings.* London: E & FN Spon Press.

King, I. (1993). *Christopher Alexander and contemporary architecture.* Tokyo: A & U Publishing.

Koestler, A. (1967). *The ghost on the machine.* London: Penguin Group.

Krebs, C. J. (1972). *Ecology: The experimental analysis of distribution and abundance.* New York: Harper and Row.

Kroll, L. (1986). *The architecture of complexity.* London: B.T Batsford Ltd.

Langrish, J. (1993). "Case studies as a biological research process." *Design Studies* **14**(4): 357-364.

Laszlo, E., Laszlo, A. (1997). "The contribution of the systems sciences to the humanitites." *Systems research and behavioural science* **14**(1): 5-19.

Latour, B. (2004). *Politics of nature.* Massachusettes: Harvard University Press.

Lovelock, J. (1979). *Gaia: A new look at life on Earth.* Oxford: Oxford University Press.

Lovelock, J. (2006). "The Earth is about to catch a morbid fever that may last as long as 100,000 years." *The Independent,* 16 January.

Manzini, E. (2002). "Space and Pace of Flows." *Doors of Perception* 7: Flow: Amsterdam. [online at http://flow.doorsofperception.com/content/manzini_trans.html. accessed May 2005].

Manzini, E. (2003). "Scenarios of sustainable well being." *Design Philosophy Papers* (1): 1-12.

Manzini, E. (2004). "Enabling Solutions and Sustainability." *Enabling solutions workshops report*: 1-7. [online at http://www.edf.edu.au/Students/Changes/Enabling/Enabling%20Docs/Enabling%20solutions%20and%20sustainablity%2030.1.2004.doc. accessed May 2005].

Margolin, V. (1998). "Design for a sustainable world." *Design Issues* **14**(2): 83-92.

Martin, D. (1993). "The joining of human, earth and spirit." in Hull, F. (ed). *Earth and spirit.* New-York: Continuum.

Mathews, F. (1991). *The Ecological Self.* London: Routledge.

Maturana, H., Varela, F. (1970). *Autopoiesis and cognition.* London: D. Reidel publishing company.

Maturana, H. (1997). "MetaDesign." http://www.inteco.cl/articulos/metadesign.htm. [accessed May 2006].

McDonough, W., Braungart, M. (2002). *Cradle to cradle.* New York: North Point Press.

McHarg, I. (1997). "Natural factors in planning." in Steiner, R. (ed) *The essential Ian McHarg: Writings on design and nature.* London: Island Press.

Meadows, D. H., Meadows, D. L., Randers, J., Behrens, W. (1972). *The Limits to Growth.* New York: Universe Books.

Murphy, R. (2002). "The internalization of autonomous nature into society." *The sociological review* **50**(3): 313-333.

Naess, A. (1989). *Ecology, community and lifestyle.* Cambridge: Cambridge University Press.

Nasar, L. J. (1998). *Environmental aesthetics: theory, research, and applications.* Cambridge: Cambridge University Press.

Norberg-Schulz, C. (1980). *Genius Loci: Towards a phenomenology of architecture.* London: Academy Editions.

O'Hara, R. B. (2005). "The anarchist's guide to ecological theory." *Oikos* **110**(2): 390-393.

O'sullivan, E. (1999). *Transformative learning: education vision for the 21st century.* London: Zed books.

Odum, E. P. (1953). *Fundamentals of Ecology.* Philadelphia: Saunders Company.

Orr, D. (1992). *Ecological literacy: education and the transition to a postmodern world.* New-York: State university of NY press.

Orr, D. (2002). *The nature of design: ecology, culture, and human intention.* New York: Oxford University Press.

Pandit Lal, G. (2001). "Emergence of the human interests studies: the environmental dimension." *Proceedings of Systemica - Problems of individual emergence*, Amsterdam: Lincoln Research centre: 295-312.

Pearson, D. (1995). *Earth to spirit.* San-Francisco: Chronicle books.

Petrescu, D. (2005). "Losing control, keeping desire." in Blundell Jones, P., Petrescu, D., Till, J. (eds). *Architecture and Participation.* London: Spon Press: 43-64.

Porteous, C. (2002). *The new eco-architecture: alternatives from the modern movement.* London: Spon Press.

Rescher, R. (2002). "Process philosophy." *The stanford encyclopedia of philosophy* (Summer 2002 edition). Zalta, N. E. (ed). URL= <http://plato.stanford.edu/archives/sum2002/entries/process-philosophy/>

Salingaros, N. (2004). *Anti-architecture and deconstruction.* Solingen: Umbau-Verlag.

Sassi, P. (2006). *Strategies for sustainable architecture.* New-York: Taylor & Francis.

Schumacher, E. F. (1973). *Small is beautiful.* London: Vintage.

Sendzimir, J. (2002). "The ecologist." in Sendzimir, J., Kilbert, C., Bradley, G. (eds). *Construction ecology: nature as the basis for green buildings.* London: Spon Press.

Senge. P., Scharmer, O., Jaworski, J., Flowers, B. S. (2005). *Presence: Exploring profound change in people, organisations and society.* London: Nicholas Brealey Publishing.

Sharov, A. (1998). "Biological examples of MST's." http://pespmc1.vub.ac.be/default.html. [accessed September 2004].

Sismondo, S. (1993). "Some Social Constructions." *Social studies of science* (23): 515-553.

Slessor, C. (1997). *Eco-Tech: Sustainable Architecture and High Technology.* London: Thames and Hudson.

Smith, A. (2006). "Excelsior: Defining higher in the holarchy of life." http://www.integralworld.net/index.html?smith5.html. [accessed 26 November 2006].

Soper, K. (1995). *What is nature?* Oxford: Blackwell.

Spretnak, C. (1997). *The resurgence of the real.* New-York: Addison-Wesley.

Stake, R. (1995). *The art of case study research*. London: Sage.

Steele, J. (2005). *Ecological architecture.* London: Thames & Hudson.

Steward, J. (1955). *The Theory of cultural change: the methodology of multilinear evolution.* Urbana: University of Illinois Press.

Stewart, J. (2000). *Evolution's arrow.* Canberra: Chapman's press.

Thackara, J. (2005). *In the bubble: Designing in a complex world.* Cambridge: MIT Press.

Thayer, R. (1994). *Gray world, green heart.* New-York: John Wiley & sons.

Thelen, E., Smith, L.B. (2003). "Development as a dynamic system." *Trends in Cognitive sciences* **7**(8): 343-348.

Turney, J. (2003). *Lovelock and Gaia: Signs of life.* Cambridge: Icon Books.

Ujam, F. (1999). "Locus architecture." in O'Reilly, W. (ed). *Architectural knowledge and cultural diversity.* Lausanne: Comportements.

Ulrich, R. (1993). "Biophilia, biophobia, and natural landscapes." in Kellert, S., Wilson, E. (eds). *The biophilia hypothesis.* Washington: Island Press.

Vale, B., Vale, R. (2000). *The new autonomous house: design and planning for sustainability.* London: Thames & Hudson.

Van der Ryn, S., Cowan, S. (1996). *Ecological design.* New-York: Island Press.

Verbeek, P. (2005). *What things do: Philosophical reflections on technology, agency, and design.* PA: Pennsylvania state University Press.

Virilio, P. (1997). *Open sky.* London: Verso.

Vizel, Y. (1983). *Ecology: Principles and Processes.* Tel-Aviv: Tel-Aviv University Pub.

Waldrop, M. (1992). *Complexity.* London: Penguin Books.

Wattles, J. (2006). "Teleology past and present." *Zygon* **41**(2): 445-463.

Wilber, K. (1996). *A brief history of everything.* Dublin: Gill & Macmillan.

Williamson, T., Radford, A., Bennetts, H. (2003). *Understanding sustainable architecture.* London: Spon Press.

Wines, J. (2000). *Green architecture*. Koln: Taschen.

Winner, L. (1999). "The voluntary complexity movement." *Tech knowledge revue* (1.3 September 1999).

Wood, J. (2007). *Design for Micro-Utopias.* London: Ashgate.

Yeang, K. (2006). *Ecodesign: A Manual for Ecological Design*. Sussex: John Wiley & Sons.

Yin, R. K. (1994). *Case Study Research: Design and Methods.* London: Sage.

Supplement 1

Milestone dates of the sustainable development movement (Sassi, 2006: 4-5)

1866 Ernst Hackel coins the term *Okologie* as meaning the interlinked system of living organisms and their environment.

1901 John Muir recounts the deforestation of the redwood forests.

1962 *Silent Spring* by Rachel Carson deplores the effects of the use of Pesticides.

1968 Foundation of Club of Rome, a group of 30 professionals and academics from 11 countries united in their concern for the future predicament of humans.

1969 Friends of the Earth founded.

1971 Greenpeace founded.

1972 United Nations Conference on the Human Environment in Stockholm is followed by the establishment of the UN Environment Programme.

1972 Publication of *The Limits of Growth.*

1973 E.F. Schumacher publishes *Small is Beautiful: Economics as if People Mattered.*

1979 In *Gaia: A New Look At Life on Earth*, James Lovelock puts forward the theory that the Earth is a self-regulating organism.

1982 The United Nations World Charter for Nature is passed.

1984 World Watch Institute starts publishing their yearly State of the World publication.

1987 The Montreal Protocol to control and eventually eliminate substances harmful to the Ozone layer is signed by 24 nations.

1992 United Nations Conference on Environment and Development (Earth Summit) in Rio de Janeiro focuses on six main areas:
1. Framework convention on Climate change.
2. Convention on Biological diversity
3. Statement of Principles on Forests (unsuccessful due to US wish to confine agreement to tropical rainforests).

4. Rio Declaration of aims, also known as the Earth Charter.
5. Agenda 21, including assistance to developing countries and access to environmentally sound technologies.
6. Montreal targets brought forward.

1995 The Intergovernmental Panel on Climate Change concludes that 'The balance of evidence suggests that there is a discernible human influence on global climate.'

1996 The Habitat II conference focuses on sustainability in the city in view of the increasing urban population and trends towards a predominantly urban population.

1997 *Factor Four*, a report by Von Weizsacker et al. for the Club of Rome, illustrates how current technology can produce four times the efficiencies typical at the time and advocates environmental taxing.

1997 Kyoto Summit for Climate Change - terms for an international legally binding protocol to reduce greenhouse gas emissions are negotiated.

1999 *Natural Capitalism* by Paul Hawken puts forward and illustrates the concept of nature's value.

1999 The world population exceeds 6 billion, half live in cities, 2.8 billion live below the poverty line.

1999 The Worldwatch Institute reports that 7 out of 10 scientists believe the world is undergoing the greatest mass extinction of species in history.

2001 The EU's Sustainable Development Strategy is agreed in Gothenburg.

2001 The Bonn Agreement - 189 countries adopt the Kyoto Protocol. Despite scientific advice for a reduction of 60-80 per cent of greenhouse gases by the 37 more developed countries, the 189 signatory nations agree to reduce greenhouse gases by 8 percent of 1990 levels by 2010, whereby industrialised countries will set higher targets to allow developing countries to develop. Annually £350 million is to be provided by developed countries to developing ones. Nations can claim credits by increasing CO2 sinks, such as woodlands which absorb CO2.

2002 The World Summit on Sustainable Development in Johannesburg is regarded as unsatisfactory by environmentalists, but does set a number of goals including that for reducing by half the number (2.4 billion) of people without sanitation, and halting the decline of fish stocks by 2015.

2002 Monterrey Conference on Financing for Development - international agreement to increase the volume and effectiveness of international aid.

2004 Russia ratifies the Kyoto Protocol.

2004 Scientists warn that global warming is happening at a rate faster than previously believed.

2005 The Kyoto Protocol comes into force, but the US (the biggest Co2 polluter in the world) and Australia think it is too expensive and have not signed up.

Supplement 2

Guidelines for designing 'healthy buildings' (Sassi, 2006: 99)

-Considering health and safety on the building site

Physical comfort levels
-Considering indoor temperature relative to outdoor temperature.
-Considering relative humidity levels and their impacts on temperature.
-Providing ample natural light and good quality lighting without glare.
-Ensuring sound separation between buildings.
-Designing environmental systems that enable the users to control their environments.

Keeping the living environment pollution-free
-Avoid building boards and other materials containing formaldehyde.
-Using low VOC paints and finishes or avoiding the use of finishes.
-Avoiding materials, such as carpets, that encourage dust mites.
-Considering treating timber only if necessary and using the least toxic treatments possible.
-Ventilating spaces sufficiently to avoid a build-up of indoor air pollutants.
-Considering the risk associated with EMF.

Independence and identity
-Creating environments that help disadvantaged individuals to be and feel independent.
-Designing buildings that demonstrate consideration of all users and their particular requirements.
Ensuring building users are able to personalise and demonstrate ownership of their buildings.
-Creating environments that enable individuals to grow old comfortably and without disruption.

Restorative Environments
-Considering including peaceful and restful spaces that help rejuvenate and calm individuals.
-Providing opportunities to enjoy nature.