Order from Chaos: A Study in Spatial Dynamics

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Preface

"To see the world in a grain of sand." --William Blake

My academic pursuits have always been subconsciously underlain by an innate curiosity about the very essence of our world. Furthermore, an open mind has allowed me to examine my surroundings from a variety of disparate perspectives. These qualities, coupled with an education in landscape architecture, have provided me with a solid foundation for exploring the infinite complexity of our environment.

As I begin to mature as a creative thinker, my view of the world expands to include topics of which I had never dreamed. My last year of study-- and this project specifically-- provides a forum for the synthesis of five years of thinking and a lifetime of dreaming.
The Search for an Alternative

"Why is it that the silhouette of a storm-bent leafless tree against an evening sky in winter is perceived as beautiful, but the corresponding silhouette of any multi-purpose university building is not, in spite of all efforts of the architect?"

-Gert Ellenberger
My thesis project began not with a specific site or land use concept, but with a philosophical ideal. Through five years of study in landscape architecture I developed a deep-seated feeling that our designed environment has been "sterilized" by the hands of man. Because we lack an in-depth understanding of structure and order in nature, we have built an environment based on a simplistic ordering system—Euclidean geometry. Thus our cities have grown in response only to the grid, with little regard for the form of the landscape to which it has been applied. Individual buildings have responded in a similar manner, becoming static, rectilinear volumes within which we live and work. The designed landscape has become static as well—characterized by lines of token street trees which serve to reinforce the grid beneath them. Thus, although I realize that these statements are vast generalizations, my central point remains valid: our designed environment has, in most cases, become sterile, static and generally inhuman.

In light of such strong feelings, my philosophical ideal became a search for a new way of looking at how we design our environment. Can we begin to design more aesthetically dynamic spaces? Can we create environments that respond to a natural sense of order rather than a geometric one? Can we design our surroundings holistically— that is, can the architecture and landscape begin to function as a single integrated system?
Thus, the goals for my project became clear, yet I lacked a vehicle for pursuing them. I searched for a methodology that might yield more dynamic form, yet came up empty-handed. Although I had been exposed to the geometry of Euclid throughout my life in school and in the very structure of the environment that surrounded me, I could not convince myself that therein lay the only means of deriving the form of our built environment.

Then, one day, I opened my eyes— or should I say, they were opened for me. I had been thumbing through a book that a friend had begun reading, and I came upon a series of photographs that caught and held my attention. They were computer generated patterns which somehow seemed "natural". The forms were delicate and seemingly infinite in detail, and although the images were clearly two-dimensional, they had a depth like I had never seen before. I was even more amazed to discover that these patterns were mathematically defined using a set of simple equations, and could be precisely recreated. A close inspection revealed pattern on top of pattern, woven together to form an interconnected network of forms which were similar to one another, yet clearly unique, each somehow related to the structure of the entire set. The overall structure of each photograph seemed to imply movement, creating dynamic form in two-dimensional space. I found myself entranced by their beauty, and I realized that I had to know more.

The next day, I bought the book and began reading it in my spare time. The book, entitled *Chaos: Making a
New Science began to expand my view of the world. It offered "a way of seeing order and pattern where formerly only the random, the erratic, the unpredictable--in short, the chaotic--had been observed." (Gleick p. 355) I found that the beautiful patterns I had seen could not only be created on a computer, but similar patterns had been found to exist in the structure of many natural systems as well. I was intrigued like never before. Could this thing called "chaos" offer insights into an alternative method of achieving order in the design of our environment?
Chaos Discovered

"Clouds are not spheres. Mountains are not cones. Lightning does not travel in a straight line."

-Benoit Mandelbrot
Chaos! The word itself conjures images of excitement, mystery, and confusion. Although classically defined as "complete disorder", chaos has become a shorthand name for a fast-growing movement that is reshaping the scientific establishment. Chaos theorists have turned from the historically reductionistic trend in science--the analysis of systems in terms of their constituent parts--to a broader-based method of looking at the whole. "Although highly mathematical in origin, chaos is a science of the everyday world, addressing questions every child has wondered about: how clouds form, how smoke rises, how water eddies in a stream." (Gleick p. 355) Chaos is a science of systems--of process rather than state--of becoming rather than being.

Where chaos begins, classical science stops. Although scientists have inquired into the laws of nature for centuries, they have remained ignorant about disorder in natural systems. Disorder in the atmosphere, in the turbulent sea, in the oscillations of the heart and brain--the irregular side of nature, the discontinuous and erratic side--these have been puzzles to scientists, and typically such problems were disregarded as "random behavior". The problems of disorder, turbulence, and non-linear systems created mathematical monsters which were pushed aside because they could not be classified based upon typical physical and mathematical laws. The science of chaos offers a new way of looking at these "monsters", a method which may eventually unravel the intricate structure underlying complex systems.
Mitchell Feigenbaum, a physicist and founder of chaos theory, described his earliest encounter with the underlying order in chaotic systems while walking along the bank of a stream:

"A few dozen yards upstream from a waterfall, a smooth flowing stream seems to intuit the coming drop. The water begins to speed and shudder. Individual rivulets stand out like coarse, throbbing veins... You can focus on something, a bit of foam or something. If you move your head fast enough, you can all of a sudden discern the structure of the surface, and you can feel it in your stomach... But for anyone with a mathematical background, if you look at this stuff, or you see clouds with all their puffs on top of puffs, or you stand at a sea wall in a storm, you know that you really don't know anything." (Gleick p.157)

He describes a structure that cannot be characterized by typical scientific principles; an order that, although mathematically finite, is seemingly random and infinitely complex. Within a system which does not follow the age-old rules of physics and geometry lies an order that is much less mathematical than it is intuitive in nature. Similar behavior has been observed in a variety of natural systems, including the shapes of clouds, the paths of lightning, the microscopic intertwining of blood vessels, and the galactic clustering of stars. (Gleick p. 4) Chaos breaks across the lines that had typically separated scientific disciplines. Physiologists found a surprising order in the chaos that
develops in the human heart, the prime cause of sudden, unexplained death. Ecologists found a pattern in the rise and fall of gypsy moth populations. Meteorologists found predictability in the turbulent behavior of global weather. (Gleick p. 4)

Chaos offers insight into the universal behavior of complexity. It analyzes a system holistically, rather than reducing it to its simplest components, for the followers of chaos are bound by the belief that the whole is greater than the sum of its parts. "Simple systems give rise to complex behavior. Complex systems give rise to simple behavior. And most important, the laws of complexity hold universally, caring not at all for the details of a system's constituent atoms." (Gleick p. 304)
Dynamical Process
Jelled into Physical Form

"Simple shapes are inhuman. They fail to resonate with the way nature organizes itself or with the way human perception sees the world."

-James Gleick
My initial reading into the theories behind this new science led me to an unmistakable conclusion. Although the details at first were very sketchy, I felt that somewhere within this collection of mathematical equations and scientific jargon lay a new way of looking at the world—and a new way of designing it.

"The shapes of classical geometry are lines, planes, circles and spheres, triangles and cones. They represent a powerful abstraction of reality, and they inspired a powerful philosophy of Platonic harmony. Euclid made of them a geometry that lasted two millennia, the only geometry still that most people ever learn. Artists found an ideal beauty in them. Ptolemaic astronomers built a theory of the universe out of them. But for understanding complexity, they turn out to be the wrong kind of abstraction." (Gleick, p. 94)

For centuries, man has simplified the world around him in an attempt to understand it. He has constructed a world of rectilinear volumes in which to live—and in the process has created an environment which is unnatural and essentially inhuman. Such a world is unnatural in the sense that its form is a simplistic abstraction of reality—an abstraction generally expressed as Euclidean geometry. Classical geometric theories, although derived from "natural" forms at their inception, have been employed by civilization in a manner which is fundamentally foreign to the natural system to which they have been applied.
Benoit Mandelbrot, a Polish-born mathematician, developed one of the initial seeds of chaos theory, known as fractal geometry. The culmination of his work to date includes the computer-drawn graphics that first caught my eye, yet his philosophies about form and order in nature formed the foundation for my belief in an ordering system that could reshape the way we derive physical form in the design of our environment.

"Clouds are not spheres, Mandelbrot is fond of saying. Mountains are not cones. Lightning does not travel in a straight line. The new geometry mirrors a universe that is rough, not rounded, scabrous, not smooth. It is a geometry of the pitted, pocked, and broken up, the twisted, tangled, and interwoven. The understanding of nature's complexity awaited a suspicion that the complexity was not just random, not just accident. It required a faith that the interesting feature of a lightning bolt's path, for example, was not it's direction, but rather the distribution of zigs and zags. Mandelbrot's work made a claim about the world, and the claim was that such odd shapes carry meaning. The pits and tangles are more than blemishes distorting the classic shapes of Euclidean geometry. They are often the keys to the essence of a thing" (Gleick, p. 94).

These words etched themselves in my mind. They seemed to make so much sense, yet I could not understand why we as a society had not recognized this tremendous potential before. Was the order of nature so complex that we could not begin to comprehend it? Why have designers
seldom been able to capture those elements that characterize natural beauty and form? I was puzzled, yet my continued research into the theories of chaos gave me hope. I found that several of these theories—upon which I will expand in the next chapter—seemed to have direct application to the derivation of form in the design of our environment.

"Simple shapes are inhuman. They fail to resonate with the way nature organizes itself or with the way human perception sees the world." [Gleick, p. 117] Thus, I asked myself, why do designers continue to simplify the structure of our built environment into forms which are brutally static and inhuman? With this question in mind, I resolved to search for an alternative means of giving order to the spaces we design. In nature I found endless illustrations of truly dynamic form—form which has an underlying structure that is not definable by the typical rules of physics and geometry. Turbulence in fluids, the growth of crystals, the movement of electricity—each has a structure and an underlying ordering system which dictates its form, yet these systems are much more intuitive than they are geometric—dynamic forms articulated by natural process.

In the words of Gert Ellenberger, a German physicist: "Why is it that the silhouette of a storm-bent leafless tree against an evening sky in winter is perceived as beautiful, but the corresponding silhouette of any multipurpose university building is not, in spite of all efforts of the architect? The answer seems to me, even if somewhat
speculative, to follow from the new insights into dynamical systems. Our feeling for beauty is inspired by the harmonious arrangement of order and disorder as it occurs in natural objects-- in clouds, trees, mountain ranges, or snow crystals. The shapes of all these are dynamical processes jelled into physical forms, and particular combinations of order and disorder are typical for them." (Gleick p. 117)

Designers of the environment are in the business of creating space-- a somewhat ambiguous word which describes the infinitely complex volumes within which we live. Unfortunately, designers often fail to capture the dynamic qualities of those spaces, relegating them to inhumanly sterile and static forms. The dynamics of space are all around us-- in the aroma and rustle of fallen leaves, the dancing sunlight on a forest floor, the soft whisper of a babbling brook, and the first breath of a summer breeze. Each incorporates the movement of air, water, light, and sound to create a sensation of spatial experience that is active, vibrant, and full of vitality-- a truly dynamic space. Why is it that modern architectural and landscape architectural forms often fail to arrest those elements that characterize dynamic spaces?
Beyond Reductionism

"Every design problem begins with an effort to achieve fitness between two entities: the form in question and its context."

-Christopher Alexander
The science of chaos and the study of fractal geometry are relatively infantile in development. New discoveries seem to be arising almost daily. So far, however, research in the field has generally focused on finding order in existing chaotic systems, rather than applying the principles to create new orders. Fractal geometry is a possible exception, however, since it has been used (with the aid of powerful computers) to create infinitely detailed, mathematically defined geometric patterns. Yet, to no great extent has chaos theory been applied to solve problems in the tangible environment.

The problem lies in answering this question: how can the scientific and mathematical principles of chaos theory be applied to create tangible, physical form in the design of our environment? And furthermore, how can such forms be illustrated, understood, and applied to site-specific design problems? These questions can only be addressed by a willingness to explore and an ability to look at our world from a new perspective.

I began my search for answers by attempting to break this huge body of newly discovered knowledge down into a set of usable parts. This was not an easy task, however, because chaos theory is not describable by a strict set of hypotheses. Rather, it is a science characterized by generalities and loosely defined principles, the description of which often creates the need for new scientific terminology. However, I was able to distill several general characteristics of dynamical systems from my readings on the subject, and found that
many of them had strong correlations to the way we design space.

The study of dynamical systems, as mentioned in an earlier chapter, has led science away from its reductionistic trend toward breaking systems down into their constituent parts. Chaos is characterized by holistic system behavior. Thus, it cannot be studied as a set of disconnected pieces, because each "piece" may not demonstrate the same behavior that characterizes the entire system. The study of chaos has therefore developed a new breed of scientists who "believe that they are looking for the whole." (Gleick p. 5)

In application to the form of our built environment, I contend that design has in many cases become as reductionistic as science. Building and landscape are usually designed separately, and in most cases neither attempts to respond to the structure of the existing natural system. Thus, I realized that "looking for the whole" was as important a break-through for design as it is for science. Just as scientists are searching for "holistic system behavior" in the study of dynamic processes, so should designers search for holism in the design of the environment.

The study of dynamical systems has led to a greater understanding of their holistic nature. Yet more importantly, it has revealed an intricate structure within systems which had previously been understood to have no order at all. Thus, science has embarked on a search for order in chaotic systems, and the results have been
unbelievable. Order not only exists beneath the surface of such systems, but it exists at all scales, to a seemingly infinite level of detail. At a glance, it now seems that everything around us may have an underlying structure. If only we know where and how to look for it.

The implications of order within erratic systems are endless, and we as designers stand to gain a great deal from understanding them. We have designed a world based upon a simplistic method of classifying form, and have in the process created environments that are static and inhuman. The underlying order in chaotic systems has the potential to change the methods by which we derive physical form. Structure and order exist in nature where we never before thought possible. Thus, I believe that a renewed understanding of order is essential to the designer's ability to create dynamic form and space.

Chaos is a science of dynamic systems, and has led to a greater understanding of their holistic behavior and the infinite structure underlying their complexity. However, this structure reveals much more than a series of unconnected structural layers of sets of repetitive order across scales. Chaotic systems respond to a much more intricate ordering system, generally governed by a principle known "in the business" as self-similarity. The concept of self-similarity was coined by Benoit Mandelbrot to describe ordering systems which had similar, yet not identical, structural characteristics at different scales. The structure of succeeding branches of a cauliflower head is a good illustration of self-similarity.
However, this characteristic exists in numerous natural systems which have been studied to date.

The idea of self-similarity strikes immediate attention in the mind of a designer, for it offers a means of connecting a part to the whole without the repetition of form. Imagine, for example, a city in which the fronts of the buildings are derived from the overall structure of the city's framework, which in turn is derived from the form of the landscape upon which it is placed.

All dynamic systems involve the element of time, and the behavior of these systems, if not in perpetual motion, can be characterized by a definite beginning and end. According to chaos theory, any slight alteration of these conditions can mean a severe change in the behavior and resting state of the system after motion has ceased. Thus, dynamic systems are characterized by a sensitive dependence on initial conditions.

The applications to environmental design are clear. If we intend to sensitively "fit" ourselves into an existing natural system, then we must understand the implications of that system's initial conditions—the context to which we must respond and relate: Christopher Alexander, a renowned design theorist, stresses the importance of understanding a site's "initial condition". He states that "every design problem must begin with an effort to achieve fitness between two entities: the form in question and its context." (Alexander p. 4)

'Now that science is looking, chaos seems to be everywhere. A rising column of cigarette smoke breaks
into wild swirls. A flag snaps back and forth in the wind. A dripping faucet goes from a steady pattern to a random one... No matter what the medium, the behavior obeys the same newly discovered laws.” (Gleick p. 5) There are many principles of chaotic systems too numerous and insignificant to mention, yet the characteristics that have been layed out above provide a foundation for a lifetime of design exploration. My problem lay in finding a way to concisely and convincingly illustrate the application of these principles to the creation of physical form and space.
Research and Enlightenment

"Just as we take advantage of what is, we should recognize the utility of what is not."

-Lao Tse
What is dynamic form? What is dynamic space? The answers to these questions seemed nebulous and subjective, yet human perception allows us to distinguish dynamic form intuitively. But how? What elements of a form or space make it truly dynamic? I decided to study classical ordering systems in hopes of finding some answers.

I began by looking into the very basics of form--circles, squares, triangles--the fundamental shapes of Euclidean geometry. I studied traditional means of transforming form in design, and the types of spaces that these forms created. Further reading uncovered several principles which formed a basis for understanding the relationships between form and space. I was particularly enlightened by the words of Chinese philosopher, Lao Tse: "We put thirty spokes together and call it a wheel; but it is on the space where there is nothing that the utility of the wheel depends. We turn clay into a vessel; but it is on the space where there is nothing that the utility of the vessel depends. We pierce doors and windows to make a house; and it is on these spaces where there is nothing that the utility of the house depends. Therefore, just as we take advantage of what is we should recognize the utility of what is not." (Ching p. 106). The importance of understanding the relationship between form and space was clear, yet I still wondered why we as designers often failed to grasp such a critical concept.

"Space constantly encompasses our being. Through the volume of space, we move, see forms and
objects, hear sounds, feel breezes, smell the fragrances of a flower garden in bloom. It is a material substance like wood or stone. Yet it is inherently formless. Its visual form, quality of light, dimensions and scale, depend totally on its boundaries as defined by elements of form.” (Ching, p. 108) Form defines space--simple enough. Yet I still was not convinced that designers generally understood the importance of the relationship between the two. And furthermore, nowhere in the Euclidean ordering system had I discovered a formula for creating dynamic form and space.

Obviously, I was a bit facetious in expecting to find a formula for dynamic form, but my point is this: Euclidean geometry is a formula--a simplistic means of deriving form--and nowhere within its bounds can we find the complexity and beauty of natural order. Thus, I suspect that without an understanding of natural structure and the aesthetic dynamics that come with it, design is doomed to creating static form and space.

My study of classical ordering systems clarified my mission. The key to dynamic form lay within the structure of nature and the designer’s ability to interpret and apply it. Furthermore, the ability to interpret natural order stems from the laws of dynamic systems set forth by the science of chaos. With this in mind, I began to develop a means by which I might illustrate the application of chaos theory to a specific environmental design problem.

Several days of contemplation and frustration led to the selection of a specific project type that seemed most
suitable to the task at hand. The type of project was not
critical to the success of the study, yet it was important
that the project be large enough to accommodate design
exploration at a variety of scales. I also added the slightly
subjective criterion that the proposed landuse have some
relevance to the study of chaos.

At first it seemed difficult to satisfy these criteria,
but soon the pieces seemed to fall together. I decided to
design a research institute for the study of chaos based
upon the scientific and mathematical principles to be
studied within it. The goal would be to create a truly
dynamic environment within which to think explore and
educate. Hence, the design process would be based upon the
premises set forth by chaos theory, including the
principles of holistic system behavior, self-similarity,
and sensitive dependence on initial conditions.

I soon realized that I knew nothing about the needs
of a research facility-- especially a state-of-the-art
campus, like this one would surely need to be. I began
looking into the process of scientific research in an
attempt to understand the needs of the people who would
be working there, and interviewed professors who had
worked in research facilities in the past. Thus, I developed
a set of programmatic needs and explored the most
efficient relationships between them.

Aside from the standard facilities necessary to
carry on scientific research, I realized that the study of
chaos was quite a different animal. Because of its
interdisciplinary nature, a chaos research center would
need to house laboratory and office space for nearly every discipline related to scientific and mathematical study. Furthermore, the fact that chaotic principles applied across the lines that typically had separated these disciplines dictated that the campus facilitate interaction and the ability to openly share information.

A series of conceptual diagrams began to reveal that a circular arrangement of facilities was the most efficient use of space and that laboratories should be grouped according to their need for interaction with other disciplines. Thus, although a microbiology lab would be located in closest proximity to the other life sciences, it would still be linked to the rest of the campus. Conceptually, this “link” was the interdisciplinary nature of chaos theory, yet it began to take physical form as information networks and pedestrian path systems in the design of the campus.

It is interesting to note that although I had studied chaos for nearly two months, the concepts that I had envisioned to this point were largely geometric in nature. I realized that the transition into a new way of defining physical form would not be an easy one. Simply seeing chaos was not enough to overcome five years of design using Euclidean geometry as a model. The application of a new ordering system would take an in-depth understanding of how order could come from chaos.
Chaos in my Coffee Cup

"Chaos delineates a whole new way of thinking about structure and form."

-Paul Davies
The need for a deeper understanding inspired a slight change of plan. Rather than continuing with the design process from concept into its physical manifestation, I chose to pursue a tangential path. I had struggled to find an appropriate means of analyzing the structure of chaotic systems, until I realized that I was approaching chaos as a designer. Thus, I decided that a more legitimate approach might involve experimentation--approaching chaos as a scientist.

I dabbled in chaos. I mixed oil with water. I dissected cauliflower. I attached toilet paper streamers to a fan. I photographed all these things, and dozens more. Yet even though I wasn't sure what I was looking for, I began to see order and pattern in places I would never have looked. Suddenly, chaos was everywhere, and the day-to-day drudgery was exciting again. I began to look at the world from a different perspective, and suddenly I began to understand.

One morning, I awoke like any other day--I showered, shaved, and started making breakfast. Half asleep, I added cream to my morning coffee and began to stir. Suddenly, I was wide awake, for in my coffee cup was beauty like I had never seen. As the cream and coffee swirled together and began to mix, I saw patterns that I had never noticed before. And if that weren't enough, these were the same patterns that I had seen pictured in Gleick's book. There was "chaos" in my coffee cup!

What I saw that morning was order and pattern as dictated by nature, not by geometry. It was scaleless and
timeless-- harmonious and dynamic-- simply beautiful. I finally appreciated the magnitude of this thing called chaos. It was a science that was broader and more far-reaching than I had imagined, and I knew there was no way to apply all of chaos theory to a single design problem. Hence, I began to focus my search. I needed a model that I could analyze in some detail and relate to the design of pedestrian-oriented space.

I recalled Mitchell Feigenbaum's experience of walking along a rushing stream and perceiving the structure of the surface. I thought about my experience with the swirls in the coffee cup. I remembered images of Jupiter's whirling atmosphere. All these were examples of dynamic fluids-- turbulent systems with a characteristic structure. I realized that the movement of people-- seemingly random, yet destination oriented-- was very similar to the behavior of a liquid in motion. Since the most important concept behind the design of this research facility was the movement and interaction of people, turbulence seemed to offer the perfect model for designing a system to accommodate movement and interaction between form and space.

I began a visual analysis of several photographs of dynamic fluids by drawing overlays which simplified their patterns into more clearly defined form. I saw similarities between forms which were very different in kind. A rod drawn through a viscous fluid in a laboratory created patterns that were very similar to those found in Jupiter's Great Red Spot. Not only was order and pattern
universal across scales, but it existed at both global and microscopic levels. The principles of chaos—holistic order and self-similarity—were no longer simply words that I had read in a book—they were reality.

Because I would be designing three dimensional form and space, I felt it was a necessity to begin to look at the patterns of turbulence in three-dimensional terms. I constructed a relief model of one of the dynamic flows with which I had been working. For the first time, I not only saw order and pattern within this system, but I saw spaces: spaces which seemed to flow together, forming an interconnected network. The shapes defining spaces also came to life, and within them, I began to see a hierarchy of form.

Things had begun to fall together, and I realized the importance of understanding the three-dimensional structure of dynamic systems—they were no longer simply two-dimensional patterns. Yet while I knew that I had opened a multitude of opportunities for exploration, I had also doubled the complexity of the problem. The success of the project now lay in my ability to apply the characteristic order of turbulent systems to the site-specific design of the research facility. Easier said than done.
The Interaction of Forces

"The iterating of these lines brings gold; the framing of this circle on the ground brings whirlwinds, tempests, thunder and lightning."

-Christopher Marlowe
from Dr. Faustus
The application of the principles of turbulence to a specific site dictated that the site be thoroughly analyzed and understood. Yet, a typical broad-brush site analysis was not appropriate in this case, because an in-depth understanding of the site's existing structure was a necessity to the creation of a conceptual structure for development. However, understanding the site as a system was a large undertaking in itself. The ambiguous word "site" is a simplistic way of referring to a very complex interaction between the natural systems of vegetation, hydrology, topography and soil structure, to mention only a few. Thus, it became necessary to simplify the system to be analyzed.

I decided that since this study was basically an exercise in the derivation of form, it was most important to concentrate on the form of the site--its topography. It should be noted, however, that similar analyses of the other site systems would also be necessary if a more in-depth study were undertaken. Hence, I built a topographic model of the site, and began to make observations about its existing form and the forces that had sculpted it. An understanding of the natural forces acting on the site gave me clues as to how the "forces of man" might interact with the existing natural system.

I soon found several similarities between the form of the site's topography and the structure of the dynamic systems that I had been studying. It was difficult to pinpoint a specific resemblance, yet intuitively the characteristics of holism and self-similarity seemed to
relate to the structure of the site in the same manner that they had existed in the structure of turbulent fluids. Such a relationship was possible, after all, since the landscape acts in many respects as a liquid, changing its shape in response to the forces acting upon it. Thus, I concluded that the topography of the site itself created an ordering system to which all development must respond.

This was a drastic decision yet I felt it was necessary to define a set of parameters that would begin to guide the development of physical form. Chaos theory establishes that systems behave holistically. Thus, it was important that this research facility not only function as an integrated system itself, but as a part of the existing natural system as well.

The most significant step in the design process became the development of a conceptual ordering system—a "master plan"—for the layout of the entire campus. This structure would become the "system" to which all elements in the design of the campus—buildings, walkways, roads, plantings, plazas and parking lots—must respond. Therefore, I spent weeks sketching, analyzing, and revising the master plan alone. I struggled to find the solution that blended the programmatic needs of the research facility with the existing topographic structure.

After weeks of struggle, I realized that I had to move on. It was important not only to develop a conceptual ordering system, but to show how that system would influence the creation of three-dimensional form. Furthermore, the design had to reach a level of realism
and detail to which the lay person could relate. Otherwise, my "conceptual ordering system" would be nothing more than a "pretty picture" with no connection to the issues of environmental design. With that I dove head first into the study of how this two-dimensional pattern might become three-dimensional form and space.
Environment as System

“They believe that they are looking for the whole.”

-James Gleick
Spatial form is very different from planar form, and as I mentioned earlier, this study became very complex when it leaped into the third dimension. However, it was also clear that the same principles of order in dynamic systems that applied to two-dimensional form would act similarly in space. Thus, I began to explore the possibilities for creating architecture from the ordering system that I had developed in the master plan.

How could the form of the research facility be derived from its context? The key to the derivation of "natural" form lay in allowing it to "grow" from the site in response to the established ordering system. Such a method allows for the creation of an integrated whole, in which designed elements seem to "fit" within the existing landscape, rather than imposing themselves on it.

I built a study model of a structural idea for architectural from in hopes that it might begin to create an image of this "place" in my mind--a concept that I had been quite removed from thus far. How would it feel to work here? How would it feel to visit this campus for the first time? I found the model very beneficial in helping me to visualize the three-dimensional form of the architecture, yet it represented only a small "slice". How could the entire campus be perceived as an integrated whole?

I reverted back to studying the conceptual plan for the campus, and looked for hierarchies and systems of interconnected space within it. Now that I had jumped
into a vision of three-dimensional form. I began to see buildings, courtyards, and trees in place of the abstract forms that had comprised the original concept. And even though the exact placement of buildings was not at all clear at the start, they had "grown" from within the structure of the ordering system. In many ways, this method was no different from overlaying a grid on the entire site and letting it establish order. However, the critical distinction arises from the fact that this ordering system was derived from the structure of the site itself, not from the geometry of Euclid.

Within this integrated whole, I found uniqueness. Each group of laboratory buildings had a clearly individual character, yet their forms were linked by an underlying structural thread. Furthermore, the network of exterior spaces seemed to flow across the landscape as a fluid, connecting one courtyard to another, each providing a unique aesthetic. Circulation systems weaved through the campus, forming a spine to which the buildings seemed to cling. In many ways, I had achieved my goals of providing for interaction within a diversity of spatial experiences.

The campus seems more like a living organism than a machine, and in that way I feel I have been successful. The underlying structure provides for flow between form and space in much the same way that natural landscapes blend into one another. It is often difficult to distinguish the built forms of the campus from the existing form of the landscape--a perception that is
witness to the underlying order from which they are both derived.
Epilogue

"Man and nature coexisting in a world designed holistically."

-Anonymous
Aside from all it has accomplished, this study is but the tip of the iceberg. Its message lies not in the design of a research facility, for it looms much larger and cuts much deeper than that. This project was viewed as an exploration. It does not attempt to offer a final solution, but focuses on a written and graphic documentation of a single case study which can be followed and used by other designers to stimulate a new way of looking at the design of our environment. It is an attempt to look beyond man's historically destructive attitude toward the environment by emphasizing the need for humanity to function within a larger natural system. Furthermore, the study focuses on the development of built form which responds to its context in a way that is functionally and aesthetically harmonious with the structure of that system.

Although the issues addressed by this study are very broad and in many respects unexplored, the importance of their exploration is obvious. The scientific community now stands on the cutting edge of a new field of study. The accumulation of knowledge about order within chaotic systems is growing on a daily basis. This knowledge, however, awaits application to countless problems within many fields of study. The significance of this new science has already been felt in the areas of medicine, meteorology, physics, chemistry, and engineering. Yet to no great extent has it been applied to the fields of environmental design—architecture, landscape architecture, and urban planning.

In an age when our society faces the destruction of
itself and the earth it inhabits, we must strive to gain a better understanding of the natural system within which we live. That system does have an order and a structure—no matter how complex—that we must attempt to comprehend. Once we begin to grasp the essence of nature, we will indeed be better suited to live in harmony with it.

An understanding of the natural system may unlock the secrets to its intrinsic beauty, and allow us to create a built environment which is aesthetically and structurally similar to that of nature itself. Only then will we be able to design cities which are truly an integrated part of the environment surrounding them. The result: man and nature coexisting in a world designed holistically.
Sources Cited


References


