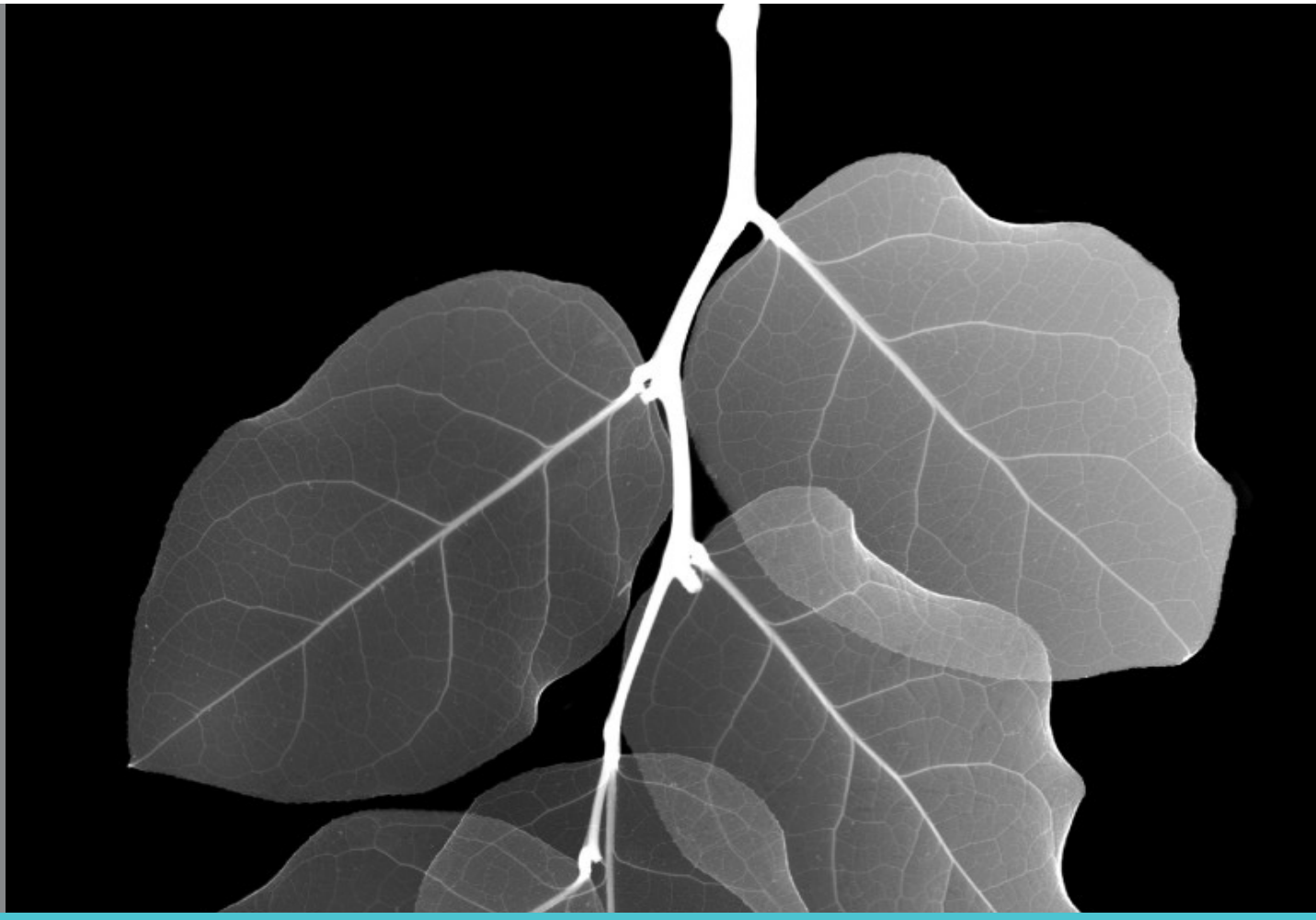

A BOOK OF ABSTRACTIONS

FROM ECOLOGY TO ARCHITECTURAL DESIGN: A FRAMEWORK FOR TRANSLATION OF ECOLOGICAL

Prepared for:
Advanced Architectural Design Studio
North Dakota State University

Kaitlyn Aberle

A RESEACH REPORT

FROM ECOLOGY TO ARCHITECTURAL DESIGN: A FRAMEWORK FOR TRANSLATION OF ECOLOGICAL PRINCIPLES

This paper is part of an on-going research study in the field of architectural design that is attempting to bridge the gap between ecology and design of the architectural environment. The study of architecture and ecology together is a way to approach the built environment as a more dynamic system that responds to the needs of the inhabitant. It is positioned in such a way that by studying the organization of successful ecological processes of natural organized systems, an innovative set of design principles can be implemented successfully in the practice of architectural design. This report will begin by analyzing the natural processes that are a part of ecosystems and then, with architecture as the vehicle, explore if it is possible to create a new model that will shift the paradigm toward a more dynamic and responsive built environment.

Through a comparative literature study and compiling, reviewing, and analyzing ecological principles, the research results have report has been broken down in to six principles. These principles will be used as a framework for understanding how ecology can be abstracted as a design methodology. This research report shows how this innovative model will allow the architectural profession to go beyond sustaining current practices and encourage natural ecological processes as a vital component in built environment.

Kaitlyn Aberle
Graduate Student of Architecture
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CONTENT

ARCHITECTURE HAS THE ABILITY TO AFFECT OUTCOMES AS IT CAN INFLUENCE THE WAY WE RELATE TO OUR ENVIRONMENT BY INSPIRING AND DELIGHTING US. IT SHOULD PROMOTE MENTAL STATES THAT LEAD TO DISCOVERY, IT SHOULD ALLOW US TO UNDERSTAND AND CREATE, AND IT SHOULD, MOST OF ALL, SUMMON THE BETTER ANGLES OF OUR NATURE (ROBINSON & PALLASMAA, 2015, P. 98). AS HARRY MALLGRAVE SAID IT BEST, IN HIS CHAPTER EXCERPT FROM MIND IN ARCHITECTURE (2015), "WE JUDGE A WORK OF ARCHITECTURE TO BE BEAUTIFUL BECAUSE IT MIRRORS THE BASIC CONDITIONS OF ORGANIC LIFE (P.24)." THE CONCEPT OF ECOLOGICAL ARCHITECTURE SUGGESTS THAT CONSCIOUS DESIGN OF SPATIAL ENVIRONMENTS CAN ENCOURAGE APPROPRIATE MOODS OR ATMOSPHERES TO FURTHER OUR WELL-BEING. AS THIS TOPIC GAINS SUPPORT AND MOMENTUM, THERE WILL BE THE NEED FOR MORE COMPREHENSIVE RESEARCH AND APPLICATION TO PROVE WHY THIS PREMISE SHOULD BE APPLIED AS A WELL-ESTABLISHED DESIGN PROCESS. BY ANALYZING ECOLOGICAL SYSTEM IN COMBINATION WITH ARCHITECTURE, THE OBJECTIVE IS TO SYNDICATE EXISTING THEORIES INTO ONE SOLID FRAMEWORK FOR ANY TYPOLOGICAL DESIGN.

THE REALISTIC AND PRACTICAL APPLICATION OF ECOLOGY AS A DESIGN TOOL HAS BEEN LARGELY UNREALIZED IN THE BUILT ENVIRONMENT. ECOLOGICAL PRINCIPLES HAVE LARGELY ONLY BEEN APPLIED IN THE ENGINEERING OF PRODUCTS OR MATERIAL DESIGN. BASED ON THE FOLLOWING RESEARCH FINDINGS, IT MAY BE POSSIBLE TO IMPLEMENT ECOLOGICAL DESIGN INTO AN ENTIRE ARCHITECTURAL ENVIRONMENT. IT IS INTENDED THAT THIS ECOLOGICAL DESIGN THEORY IS INTERPRETED IN THE FORM AS A SET OF GUIDELINES THAT CAN BE IMPLEMENTED THROUGH ARCHITECTURAL DESIGN. TO AID IN THE STUDYING OF ECOSYSTEMS AS ENTIRE ORGANIZATION, A NUMBER OF PRINCIPLES HAVE BEEN IDENTIFIED THAT CAN BE TRANSLATED INTO ARCHITECTURAL DESIGN. ALTHOUGH THERE ARE MANY ECONOMICAL AND SUSTAINABLE ADVANTAGES TO DESIGNING WITH ECOLOGY, THEY WILL NOT BE INCLUDED IN THE SCOPE OF THIS REPORT. ALSO, THE PHYSIOLOGICAL AND NEUROLOGICAL EFFECTS OF ECOLOGICAL DESIGN MAY BE REFERENCED BUT WILL NOT BE DISCUSSED IN DETAIL.

THE PROCESS OF HOW THE DESIGN WILL FUNCTION IS YET UNKNOWN AND THE PREMISES ARE VIEWED AS SUPPLYING STRONG EVIDENCE FOR THE CONCLUSION, THEREFORE, INDUCTIVE REASONING IS GUIDING THE RESEARCH RESULTS. THIS ANALYSIS IS DIRECTED BY CONSTRUCTIVISM BECAUSE THE DEFINING ELEMENTS WILL BE DETERMINED BY CREATING A COMMON UNDERSTANDING OF EXPERIENCES AS HUMANS INTERACT WITH THE WORLD AND THIS REPORT WILL TRANSLATE THOSE INTO IMPLEMENTABLE CHARACTERISTICS. THE SCOPE OF MY RESEARCH WILL IMPACT THE ECOLOGICAL FIELD AS ECOLOGISTS AND SCIENTISTS FROM OTHER DISCIPLINES WILL BE CHARGED WITH IDENTIFYING PRINCIPLES FOR THE DESIGNERS WHO CREATE THE BUILT ENVIRONMENT. THIS IS A MULTI- DISCIPLINE TOPIC THAT WILL NEED THE COOPERATION OF MANY FIELDS OF STUDY IF WE WANT TO BRIDGE THE GAP AND ELIMINATE THE NOTION OF ARCHITECTURE AS BEING A SEGREGATED DISCIPLINE. I HOPE TO CLOSE THE GAP BETWEEN PEOPLE AND ARCHITECTURE TO GIVE THEM WHAT THEY DESIRE, NEED, AND HAVE BEEN ASKING FOR. THESE DESIGN GUIDELINES CAN BE BECOME A FRAMEWORK FOR ALL LIVING ENVIRONMENTS.

"AS SUCH, IT PROVIDES SCIENTIFIC EVIDENCE FOR THAT SOARING SENSE OF ONENESS WE FEEL WHEN WE WALK IN THE WOODS. THE GROUND, THE TREES, THE AIR, AND OUR OWN SELVES ARE INDEED CONNECTED."

THE REALISTIC AND PRACTICAL APPLICATION OF ECOLOGY AS A DESIGN TOOL HAS BEEN LARGELY UNREALIZED IN THE BUILT ENVIRONMENT.

BACKGROUND

ARCHITECTURE & ECOLOGY

Architecture and ecology are not two disciplines you would typically think of working together, especially in traditional architectural practice. With the topic gaining popularity and support through research studies, it is kind of unbelievable that there should of ever been a rigid separation between the two. Looking back through history, there was more support for architecture being appreciated as a scientific discovery. Up until the 8th century, architecture was viewed as much a science as it was an art. As modernity continued to follow with the changing times, architecture's connection to the sciences seemed to stray. Now, in the digital, technological world of today's 21st century, we are slowly realizing the need to shift back towards traditional roots to fully understand what makes us connect to our built environment.

JANIE BENYUS

Natural science writer Benyus, developed the basic thesis that humans should always emulate nature in design. Her work has been instrumental in leading innovative "natural models to design sustainable products, processes, and policies that create conditions conducive to life."

MAIBRITT PEDERSEN ZARI

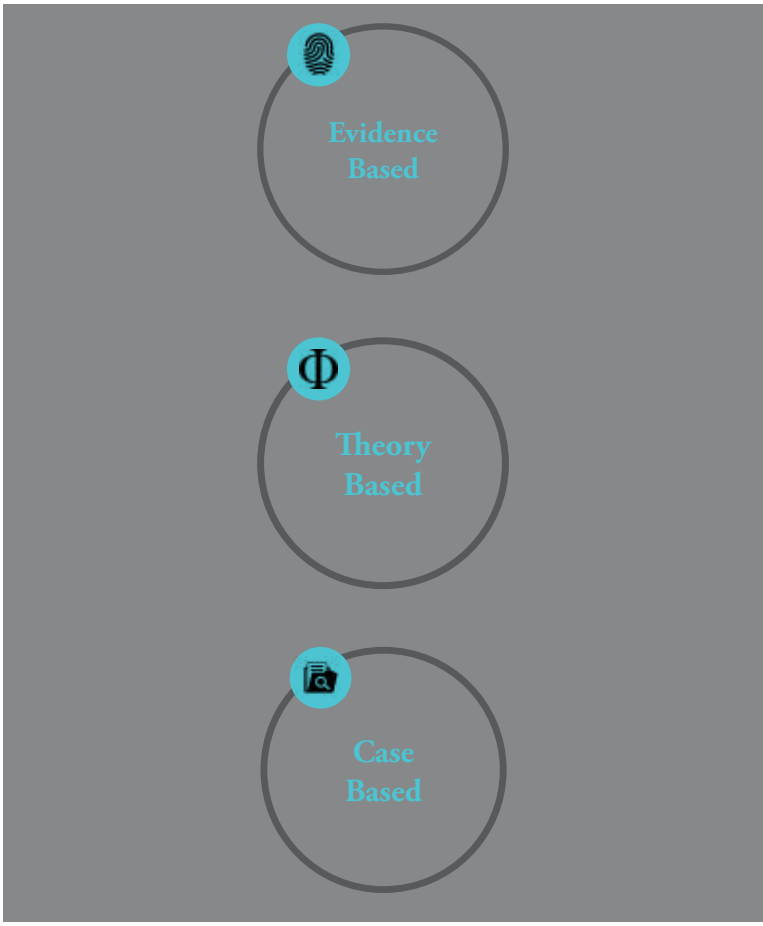
From the School of Architecture at Victoria University, Zari has been instrumental in providing research publications in the field of biomimicry and ecology in relation to architectural design. Building on her research, this report will contribute more to the practical application in architectural design.

BIOMIMICRY

The term biomimicry, sometimes, has been associated with the slavish copying of organisms, instead of the practice of learning from natural design processes. This process is a more comprehensive way of looking towards ecology to allow the built environment to become a dynamic system.

Ecological Architecture

Ecological architecture, instead, interprets, adapts, and derives design from ecological processes. This process may not appear to be immediately similar but utilizes the same functional concepts

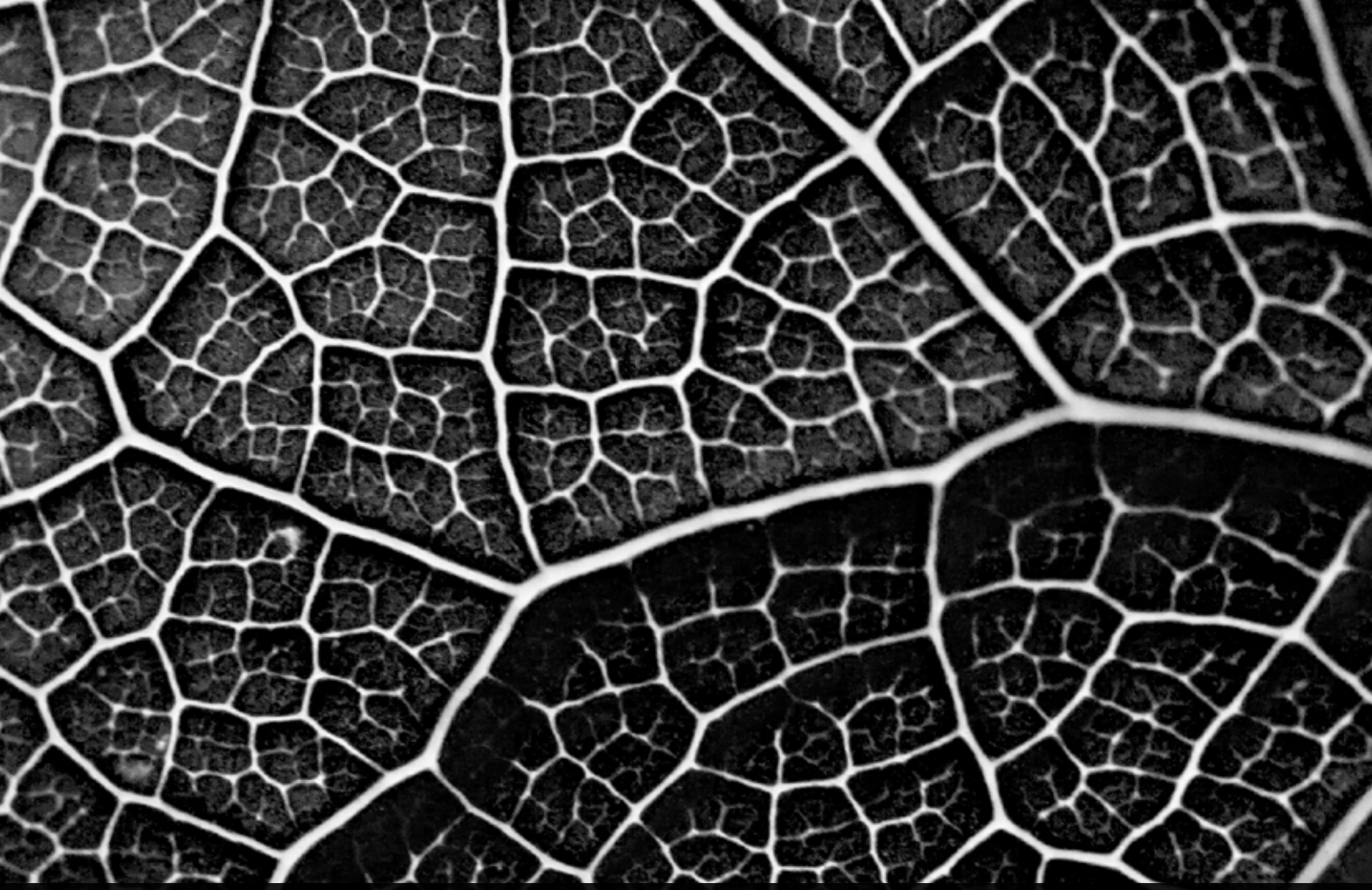


Research Process

While existing research articles have contributed mostly to evidence and theory based research, the integrated design process will provide a human experience aspect to complete the intent of the theoretical framework. By conducting comparative research of the related knowledge of ecosystem principles in the varying fields of ecology, biology, and architecture a group of principles aimed at capturing a cross disciplinary understanding of how ecological systems function was formulated. It is intended that this ecological design theory is interpreted in the form as a set of guidelines that can be implemented through architectural design to aid in the creation of dynamic environments. Because of the complexity and interconnected nature of ecosystems and the way in which they function, it is complicated to organize a neat list that accurately captures the function of a living system in its entirety. It is easier and more beneficial, for the length of this study, to generalize the basic principles and organization of functioning ecosystems and extract the abstract ideas rather than detailing exact processes and mechanisms of evolution. It best to exam relationships and the interactions within a system. Understanding the organization and structure will inform architectural design that is based on a comprehensive network of design principles.

RESEARCH RESULTS

The research and report were conducted and written from the background perspective in architectural education. The results will show the effective simplicity of the abstraction of principles to be aimed for use by designers with little to no previous education of ecology or biology. These results are aimed toward the architectural discipline as a starting point for inspiration and further investigation. There is much established research about successful functioning ecological principles, but research is lacking in the application of an architectural setting. These principles are intended to be easily understood and practicable to apply. Transforming them into a set of design guidelines will ensure that they can be used at all stages of the design process.



1 | ECOSYSTEMS ARE DEPENDENT ON NATURAL ENERGY SOURCES

ORGANISMS USE THESE TYPES OF FREE ENERGY TO SUSTAIN LIFE

The most basic and well-known principle for sustaining life is that ecosystems are dependent on natural energy sources including sunlight, wind, water and biomass.

Sun

The leaves of some deciduous trees, like an olive tree, optimize sunlight. The exterior leaves of a canopy are different from those on the interior.

Wind

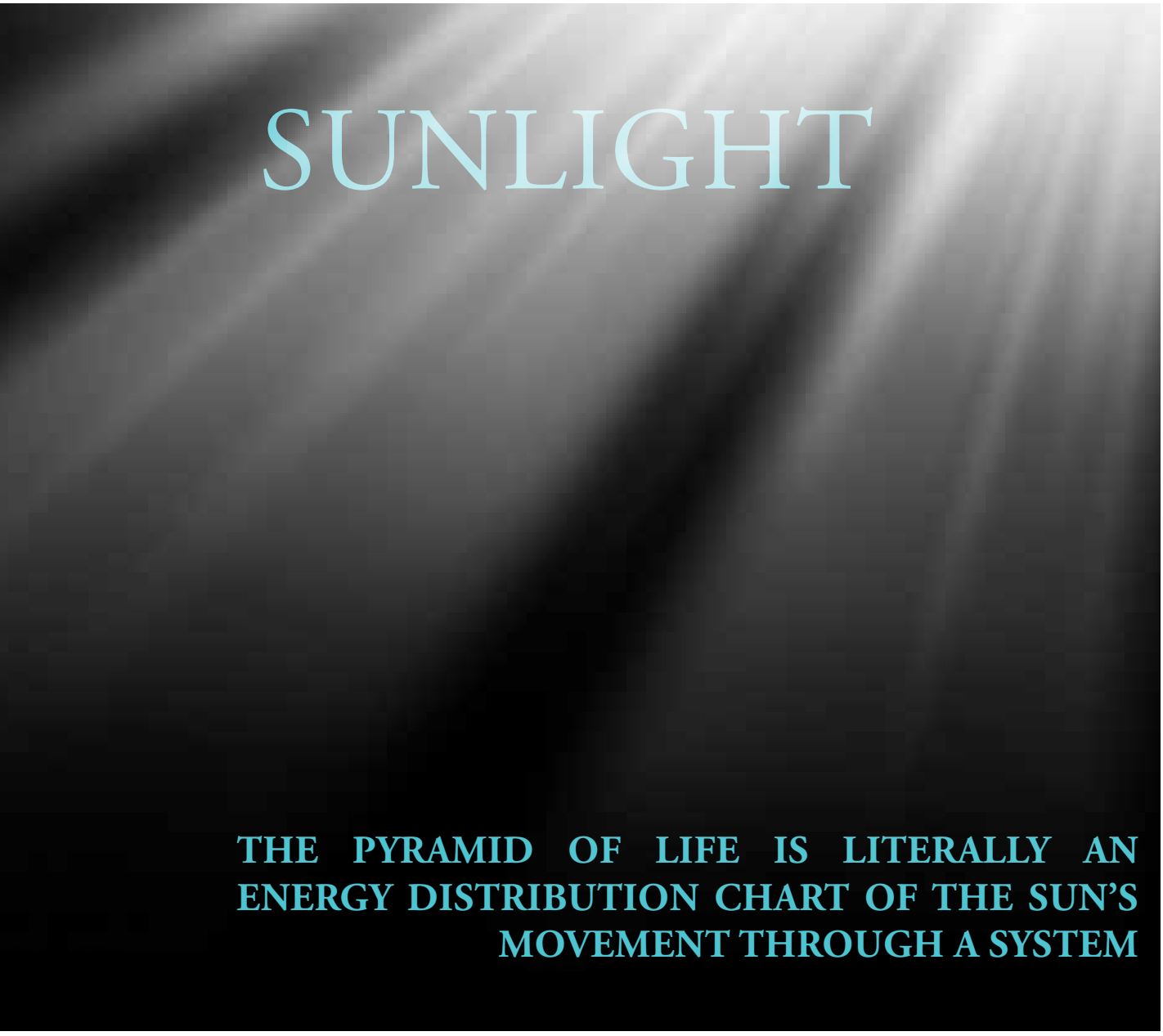
Marine mammals exploit water currents in migration

Water

Wind disperses seed pods using air currents

Biomass

When burned, the chemical energy in biomass is released as heat.



SUNLIGHT

THE PYRAMID OF LIFE IS LITERALLY AN ENERGY DISTRIBUTION CHART OF THE SUN'S MOVEMENT THROUGH A SYSTEM

The role of weather and rain patterns are important for organizing ecosystems by determining where and in what formation organisms inhabit microclimates. If the built environment was based solely on the principle alone, energy should be sourced from sunlight through the use of photovoltaics. However, we can interpret this most basic principle to consider more integrated applications.

Except for the gravitation effects of the moon, solar radiation is the only input into the closed loop ecosystem of earth. It is the only source of energy for organisms that they receive either directly or indirectly

ORGANIZATION

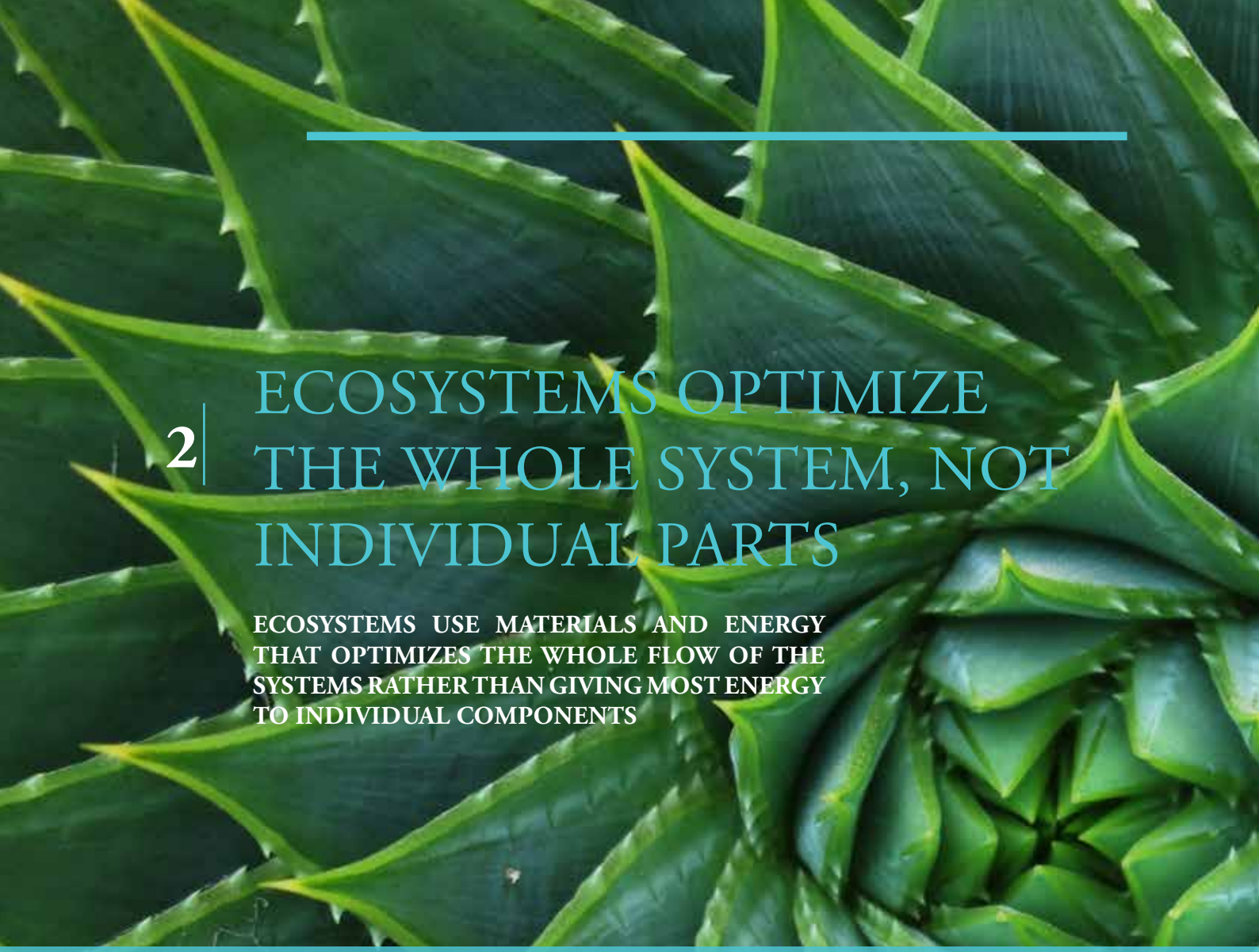
Not only are systems dependent on natural sunlight as an energy source, but the sun is also a spatial and time organizing mechanism. Biological rhythms including our circadian, diurnal, annual, or longer are determined by the sun's gravitational effect and the rotation of the earth. Animals migration patterns or flowering seasons are examples of responses to these cycles

ORIENTATION

The situation and orientation of a structural form on a building site is important so that the most 'free energy' is maximized.

FENESTRATION

Architectural design intends to get sunlight as deep into the building as possible. It is also important to maintain a uniform distribution of light while avoiding occupant discomfort and reducing glare.



2 ECOSYSTEMS OPTIMIZE THE WHOLE SYSTEM, NOT INDIVIDUAL PARTS

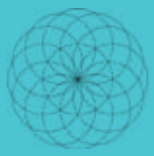
ECOSYSTEMS USE MATERIALS AND ENERGY THAT OPTIMIZES THE WHOLE FLOW OF THE SYSTEMS RATHER THAN GIVING MOST ENERGY TO INDIVIDUAL COMPONENTS

The behavior of the whole system is determined by the behavior of the individual parts. Biosystems degrade energy in a large number of small parts, unlike in human systems where energy is degraded in a small number of large steps. These pathways of dissipation are highly deliberate in nature and important to the whole system so that energy use in maximized. Only essential material and energy is used to create a structure that is necessary for the function of that system in that environment.

NATURE IS GOVERNED BY THE TENDENCY TO GENERATE SHAPES AND DESIGNS THAT EVOLVE IN TIME TO REDUCE IMPERFECTION

GEOMETRY AND RELATIVE PROPORTIONS ARE EXAMPLES OF MAXIMIZING MATERIAL AND ENERGY USAGE BECAUSE GEOMETRY PATTERNS ARE FOUND IN ALL KINDS OF ELEMENTS IN THE ENTIRE UNIVERSE.

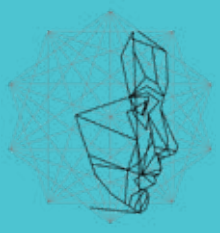
From under a microscope, living cells reveal a high orderly system of shapes and patterns. The proportions of the human body and facial relationships carry a form of proportions and symmetry. Geometry is found in flora and fauna, gems and stones, and even in space.



FLORA

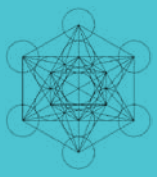
FAUNA

GEMS & STONES



HUMAN FACE

HUMAN BODY



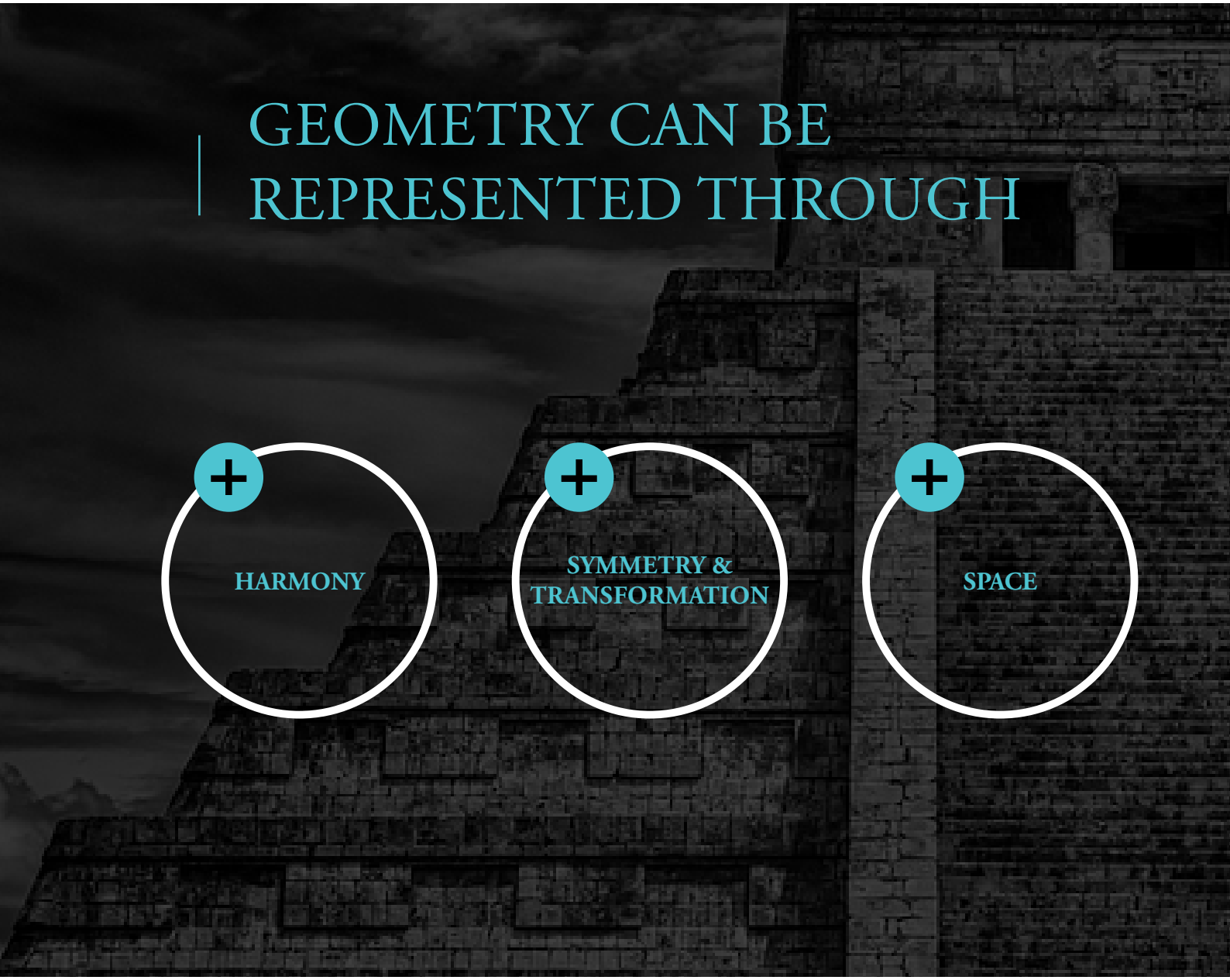
SPACE

THE WHOLE

IS GREATER

than the sum

OF ITS PARTS



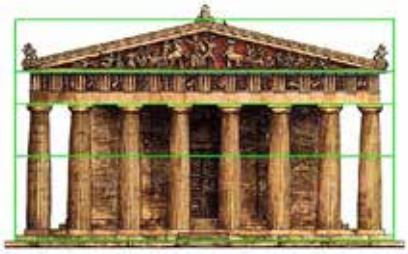
FOUND IN NATURE AND PRACTICED IN ARCHITECTURE, GEOMETRY IS AN EFFECTIVE WAY FOR THE ORGANIZATION OF A SYSTEM TO MAXIMIZE ENERGY USE, MATERIAL, TIME, OR MOVEMENT. LUCKILY FOR US, THIS WAY OF MAXIMIZING FUNCTION RESULTS IN AN AESTHETICALLY BEAUTIFUL DESIGN. FROM THIS, NATURE INTRINSICALLY MAKES CLEAR THAT FORM FOLLOWS FUNCTION. FROM A NEUROLOGICAL PERSPECTIVE, ACCORDING TO MARK JOHNSON FROM HIS CHAPTER IN MIND IN ARCHITECTURE *"ANY ENCOUNTER WITH AN ARCHITECTURAL STRUCTURE BEGINS WITH A FELT QUALITATIVE SENSE OF OUR WHOLE SITUATION PRIOR TO ANY DEFINITE ATTENTION TO COMPONENT PART, RELATIONS, OR QUALITIES."* **SO, IT SEEMS THAT THE HUMAN SUBCONSCIOUS HAS AN INNATE SENSE TO REALIZE THIS BEFORE OUR CONSCIOUS CAN RECOGNIZE IT.**

"SHAPED BY THE SAME UNIVERSAL FORCE, EACH SUSTAINS THE WHOLE IN A GRAND SYMPHONY OF CREATION"

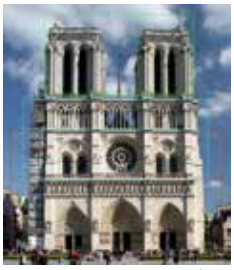
HARMONY

Harmony is a principle of composition, defined as a the "connection of different or opposed things to an arranged whole."

Within this composition of harmony, the golden ratio may be the most well-known geometry principle in the art discipline. The golden section of 1:1.6 is the most pleasing on the eye because we scan things more quickly on the horizontal than the vertical. This order is the most efficient flow, meaning the greatest ease on the eyes in shortest amount of time.



Proportions found at the Parthenon in Greece

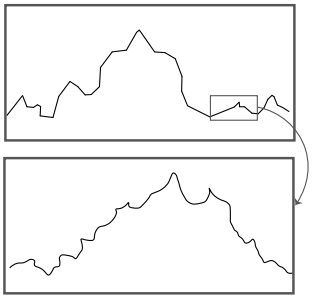


Harmony represented at the Notre wdral in Paris

SYMMETRY & TRANSFORMATION

Architectural composition is concerned with the progression of interesting forms to maintain attention through symmetry and transformations. Interesting details should express the overall intent of the composition

This is a fractal concept found in nature. Fractals are the formal progression of self-similar details from large to small scale. Architecturally speaking, fractal dimensions give a quantifiable measurement to generate rhythms and patterns used in design.



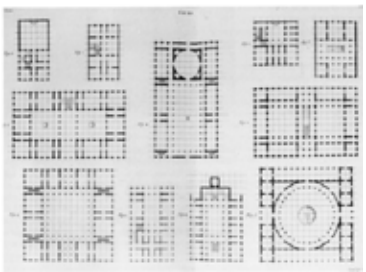
example of fractal inspiration from a mountain

Micheal Schirber's engineering structure at Stuttgart Airport in Germany

SPATIAL ORGANIZATION

Robin Evans describes the importance of the relationship between geometry and architecture: "The first place anyone looks to find geometry in architecture is in the shape of the building. [This is] where geometry has been on the whole… But geometry has [also] been active in the space between."

Projective geometry as described by Leopold, has roots in measurements and corresponds to tactile space, visual space and therefore refers to perception. Projective geometry suggests that geometry is located in the mind. "Between geometry and architecture, we seem to have somehow hopped from inside the mind to outside. So, when dealing with architectural geometry, we seem to be dealing with this route or doorway between mental and real"



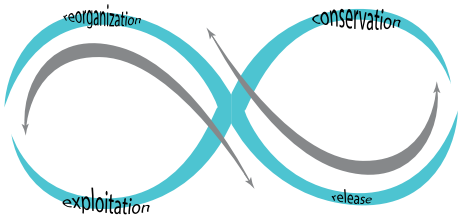
Jean-Nicolas Durand's orthographic projection of frontal and rectilinear geometry

Zaha Hadid's project 'Phaeno Science Center' in Wolfsburg, Germany

3 ECOSYSTEMS BECOME DEPENDENT ON AND RESPOND TO LOCAL CONDITIONS

WHEN DESIGNED, BUILDINGS ARE USUALLY CREATED FOR A PARTICULAR PLACE, IN RESPONSE TO CLIMATE, CULTURE, HISTORY, THE LANDSCAPE, AND THE PEOPLE

Ecosystems become dependent on local conditions by sourcing and responding to what is around them through feedback loops created within a system.



For organisms in an ecosystem, adaptation is critical for their survival. An organism that is well adapted, thrives in its environment and therefore has a higher chance of survival. It is because organisms utilize local resources that they become adapted to their microclimate. The conventional ecological view that life adapts to the local environment gives justification that organisms and the ecosystem that they create is accustomed and best suited to the environment they exist in.

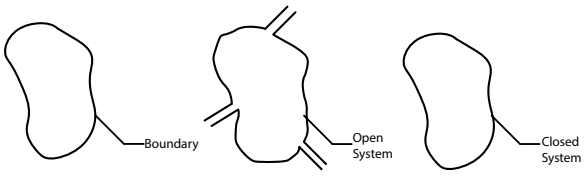
BUILDINGS NEED TO ALSO ADAPT TO THE LOCAL AND SOMETIMES LARGER ENVIRONMENT THAT THEY RESIDE IN.

The construcal law defines the word 'system' as a "region in space quantified for observation for analysis"

A TREE IS A SYSTEM, BUT THE FOREST IN WHICH THE TREE IS A PART OF IS ALSO CONSIDERED A SYSTEM.

OPEN SYSTEMS

The boundary of a system is defined by choice of the observer. The boundary is an imaginary surface that separates the system from everything else. The 'everything else' is the environment. The constructal law defines that there are closed systems and open systems.

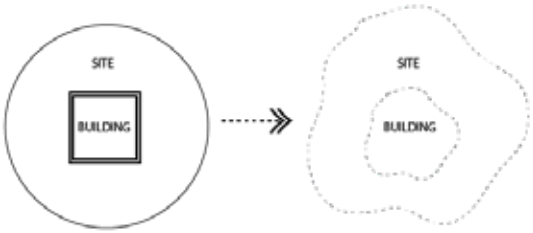


Defining systems based on the constructal law

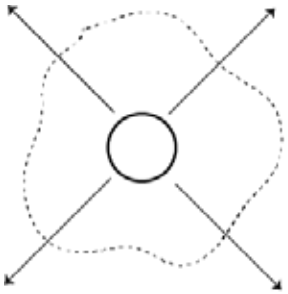
We can think of our building sites in architecture as an open system of integrated factors affecting the built environment because a building does not exist in a closed system of isolation. The outside environment must be considered in design. The constructal law reiterates the importance of place based on the interacting needs found throughout nature.

RESILIENT LANDSCAPES

In an article published by Bengtsson et al suggests that "intensively managed ecosystems tend to be depauperate and require high amounts of energy to sustain." When referring to reserves, Bengetsson et al describes the long-term goal is to create resilient landscapes of higher biodiversity. By looking at this architecturally, there should not be a defined boundary between site and building. They should be integrated seamlessly.



Transition to an open site



Graphical representation of an dynamic reserve

This is where the importance of site analysis comes into play in the architectural design processes. Even though we may see a building as a reserve, or a place set aside for special use, it should not be viewed as static and designed in isolation. Instead, it should be regarded as a part of the dynamic landscape.

4 | RELATIONSHIPS ARE MOST IMPORTANT FOR SYSTEM STABILITY

Within ecosystems, it is important to note that relationships and interacting needs are most important for system stability. All organisms within a system are connected in one way or another because each interaction depends on the one before it.

INTERACTING NEEDS

THE ORGANIZATION OF

INTERACTING LAYERS SHOULD BE

SEEN AS A DYNAMIC SYSTEM AND

NOT A STATIC OBJECT

Hierarchy is one way that living systems structure themselves to achieve self-maintenance and evolution

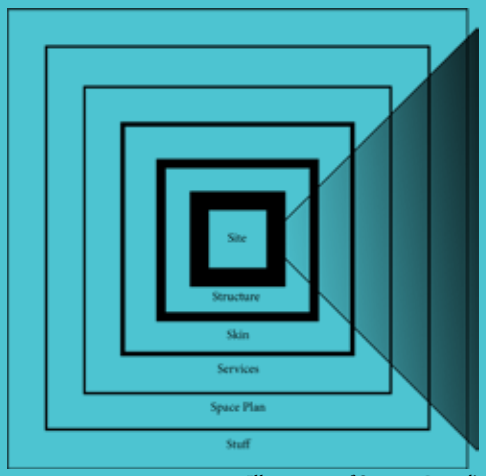


Illustration of Stewart Brand's layers of organization

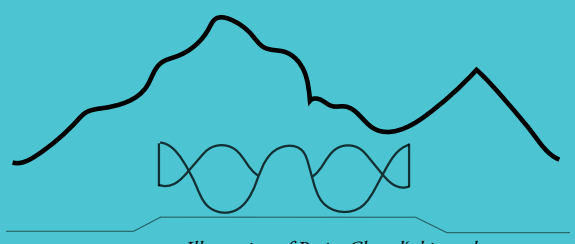


Illustration of Bosjes Chapel's hierarchy within the environment

Layers of Organization

suggests in his book How Buildings Learn: What Happens After They're Built, that buildings consist of six layers of organization. These layers are defined according to span of existence and their relationship with the users. The six layers of a building is an important example of hierarchical ordering in architecture, but the most important realization is that the building reflects the process of creation and maintenance.

Order within the Environment

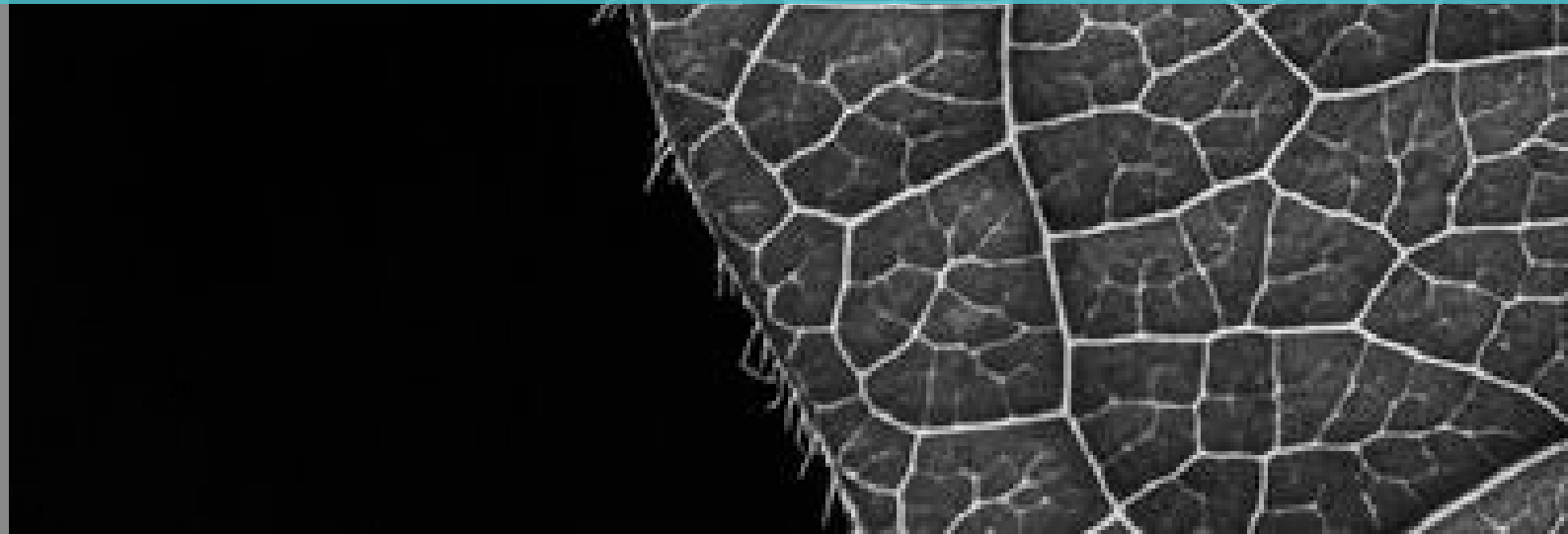
Complexity and order are characterized by the presence of rich sensory information that is configured with a coherent spatial hierarchy, similar to the occurrence of design in nature. In architecture, Stephen Kaplan interprets this experience as "how much is 'going on' in a particular scene, how much is there to look at"

5 | ECOSYSTEMS ARE CONSTANTLY ADAPTING AND EVOLVING

NATURE IS THE REALM OF ORDERED CHANGE

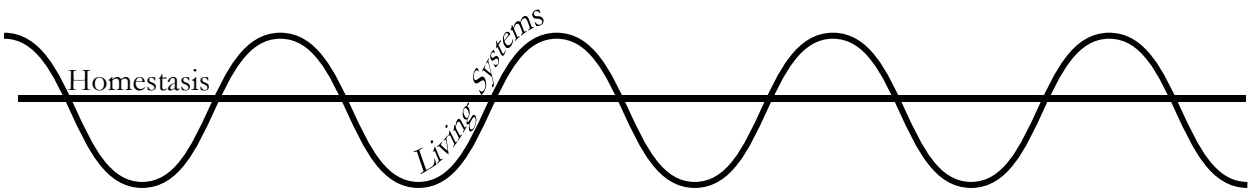
The environment is a series of overlapping and interwoven flows that interact in space and time. This forces ecosystems to constantly adapt and evolve to adjust to their surroundings to maintain equilibrium.

“There is no revolution in nature”



Evolution is happening all the time, we can witness how systems change to become better

Although, systems are always thriving to maintain equilibrium, it is never actually fully achieved. Systems are always fluctuating to maintain balance.



As Tony Burgess describes equilibrium "is not only death, it is death." As Burgess goes on to describe that "to enrich a system [there needs to be] variance in space and time"

EVOLUTION

Evolution as a vernacular term meaning incremental change over time. Just because we don't witness cellular processes happening around us daily does not mean it is a catastrophic change; nearly all change in incremental.

ADAPTATION

In an architect's attempt to keep up with the pressure to design 'awe' looking buildings or the next iconic sculpture, the building is often seen as an end solution and not a mean.

"NATURE IN THE REALM OF ORDERED CHANGE"

OUR BUILDINGS WILL NOT EVOLVE IF WE DON'T PLAN FOR THEM TO

PROGRAM

A common theme in many downtown cities is the transformation of old, massive warehouses into schools, art galleries, offices and into homes. The idea of warehouse design is universal space. Creating universal space should be the essence of any design project so that the building can adapt to meet the changing needs of activities. Stewart Brand reiterates the importance of accepting that buildings change over time and the construction process is only the beginning of a long process and not the end all solution. Adaptable buildings allow for relatively easy changeable programs and functions that fluctuate over time.

STRUCTURE

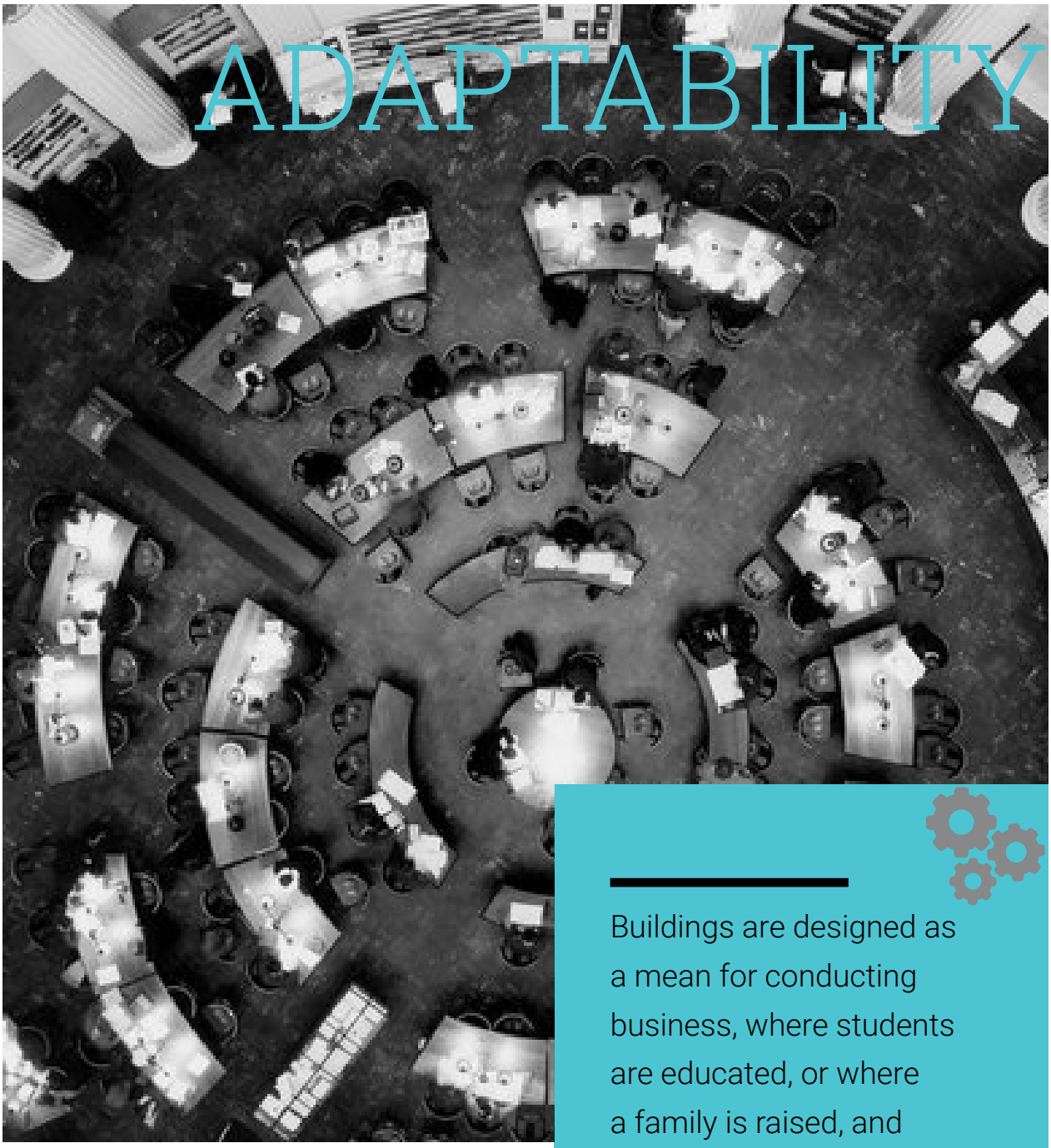
Simplicity helps to aid in future changes. Optimizing structural elements is one example on how we can let buildings evolve The structural design may be the most important element when designing for universal spaces that can adapt. A structural grid organization allows for changing space. By designing structural loads for extra carrying capacity we can allow for additional square footage to be added.

CULTURE

Along with implementing longer lasting materials and construction methods there is a cultural mentality that needs to be overcome. The involvement of the designer should last well into the operating phase so that feedback loops about programming and function are established. Greater interest in building performance and building life-cycles has led to a number of improvements of how buildings fluctuate throughout their life and how designers can improve the processes of delivering successful buildings.

If ecosystems don't adapt to change they die and become extinct- like our buildings often do

ADAPTABILITY



Buildings are designed as a mean for conducting business, where students are educated, or where a family is raised, and these buildings need to accommodate for changing cultural trends

SIMPLICITY

UNIVERSAL SPACE

STRUCTURAL OPTIMIZATION

INTEGRATED DESIGN

The involvement of the designer should last well into the operating phase so that feedback loops about programming and function are established.

6 | ECOSYSTEMS ARE ULTIMATELY TRYING TO OPTIMIZE FLOW

THE CONSTRUCTAL LAW IS A THEORY IN PHYSICS OF THE EVOLUTION OF DESIGN NATURE BY THE WAY OF OPTIMIZING FLOW IN SYSTEMS.

TRANSPORTATION SYSTEM

minimize travel time in urban traffic

DEMOCRATIC GOVERNMENT

minimization of effort & cost is the core idea of social dynamics

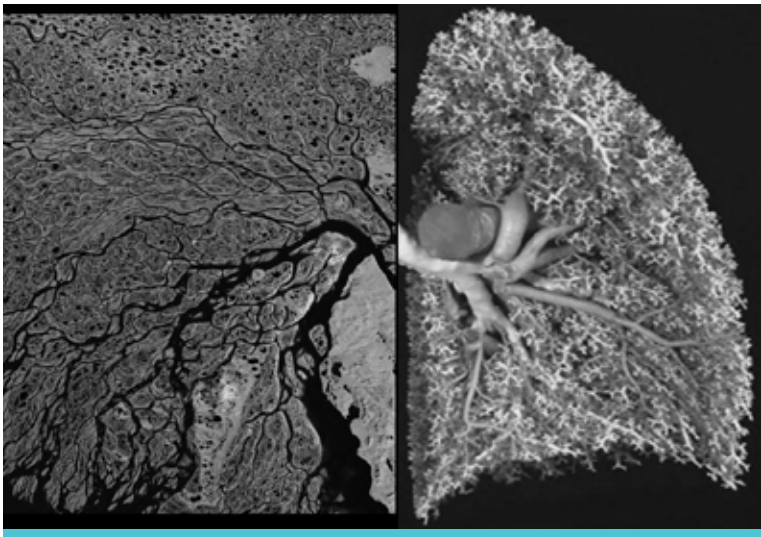
BUSINESS

maximize profit & distribution of goods & services

Because it is a law of physics- not just biology, geology, or engineering- it governs any system of the universe, any time, in any way.

The Constructal Law is the bridge between nature and

describes the flow of systems and their ability to persist in time. Flow systems are ever evolving configurations that provide easier access to currents that flow through them

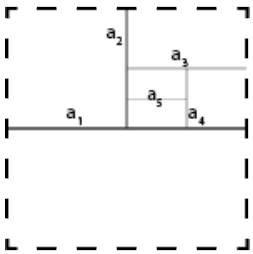


THE EASIEST WAY TO UNDERSTAND A FLOW SYSTEM IS A TREELIKE STRUCTURE. THIS PATTERN OF BRANCHES EMERGES THROUGHOUT NATURE BECAUSE IT IS THE MOST EFFECTIVE WAY TO FACILITATE POINT- TO- AREA OR AREA-TO-POINT FLOW .

STRUCTURAL SYSTEM

Depth of beams

Just as tree branches and daughter streams grow smaller in proportion of breadth and width, the depth of beams decrease in proportion to the distrubution of weight



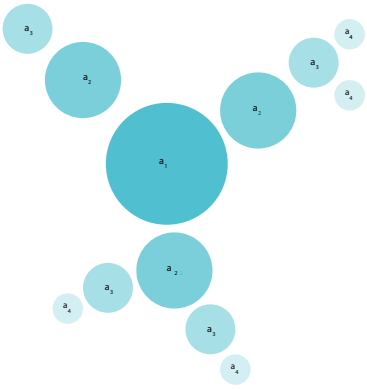
a_1:a_2: a_3:a_4

SPATIAL SYSTEM

Area of spaces

Examination of the relationship between these spaces and the users moving thought them, can help us to understand how parts of a giant jig saw fit together so neatly

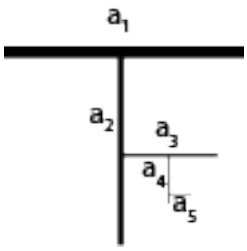
a_1-a_2: a_2-a_3:a_3-a_4



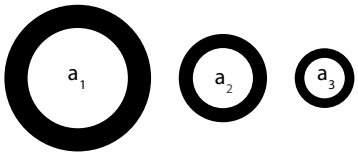
HVAC SYSTEM

Cross-section of duct work

HVAC systems in our buildings are designed so that the farther away the duct is from the main system, the smaller the cross section is because there is less flow or air to be moved.



a_1:a_2: a_3:a_4.a_5



ALL DESIGNS ARISE AND EVOLVE ACCORDING TO THIS

SUMMARY

IN CONCLUSION,

It is only when ecosystems, rather than machines, become the metaphor for design will the built environment become less of a collection of static objects in isolation and more of a dynamic system that is the result of complex design interactions. The framework proposed from this research suggests that ecology and architectural integration is more easily achieved than originally perceived. These principles are not intended as an end-of-project add-on, but rather should be viewed as an integrated design process. It is only with practice and design implementation that this design process and the benefits will be fully achieved.

Because ecosystems...

DEPEND ON NATURAL ENERGY SOURCES

OPTIMIZE THE WHOLE SYSTEM

DEPENDS ON AND RESPOND TO LOCAL CONDITIONS

FOCUS ON INTERACTING NEEDS AND RELATIONSHIPS

ADAPT & EVOLVE

OPTIMIZE FLOW

architectural design should too.

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IMAGE CREDITS

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