NIKOS A. SALINGAROS

ALGORITHMIC SUSTAINABLE DESIGN

TWELVE LECTURES ON ARCHITECTURE

A SERIES OF TWELVE VIDEOS APPLYING
CUTTING-EDGE MATHEMATICAL TECHNIQUES
TO ARCHITECTURAL AND URBAN DESIGN.

The archived videolectures are available free on the Web; see p. 253 for the links.

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INTRODUCTION

ALEXANDROS A. LAVDAS

In the early twentieth century, music, like all the arts, went through cataclysmic changes; the very concept of tonality was challenged when a number of composers started experimenting with different atonal systems. Abolishing tonality in music was tantamount to abolishing syntax in language. This is something that every composer knows and, these days, so does every cognitive neuroscientist. Unexpected notes (out of tonality) in a tonal sequence evoke the same reaction in the brain as does the appearance of syntactically wrong words in a sentence, as shown with functional MRI scans. The experiment of atonality was a purely intellectual one; it neither came from nor did it satisfy the emotional parameters that music relates to. Actually, it was not just intellectual, it was more narrowly academic: because music has been loaded with heavy intellectual content *using the language of tonality* for centuries. Atonality sought to destroy the language itself; with the language destroyed, conveying any meaning, intellectual or other, automatically becomes much more difficult.

If this story sounds awfully familiar to an audience interested in architecture, it is for a good reason. The modernist movement, and especially its deconstructivist incarnation, have arisen from the same intellectual processes and have moved towards the same language-destroying targets. There is a difference, however. The atonal movement in music did not totally dominate the twentieth century, although some composers persisted in following it dogmatically. The uncomfortable psychological effect of atonality was recognized not only by those who completely avoided it, but also by composers like Leonard Bernstein who would occasionally use an atonal theme *precisely* for this unsettling effect. Like another color in his music palette.

In architecture, modernism sought to dominate architecture and ostracize all other forms of architectural expression, by pretending it was not a style, but a totally different approach. It has both succeeded and failed in that goal. It has certainly dominated most of the 20th century but, on the other hand, its main ideological weapon — the claim that "form follows function" regardless of the aesthetics achieved — has been proven to be wrong. For modernism created its own aesthetics: Marcel Breuer's *Wassily chair* or Ludwig Mies van der Rohe's *Barcelona chair* are clearly not made in the simplest, most utilitarian manner. Some of us actually find them quite beautiful, and therein lies the ideological failure of modernism. Revealed to be, after all, nothing but just another style, with its good and bad moments, it automatically loses the moral high ground and with it the right to judge all non-modernist art as inferior or degenerate.

Nikos Salingaros argues that the Bauhaus slogan "form follows function" is, in fact a euphemism for the real agenda: "form follows purpose". And the purpose is the religious imposition of modernist principles. Modernism uses technology

to implement designs that are the product of an ideology; the system works from the top to the bottom, with technology as the intermediary.

Salingaros moves in the opposite direction. He is using science, not technology, to dissect out the multitude of parameters that have contributed, through a Darwinian selection of sorts, to pre-modernist architecture. He then uses his observations to formulate sets of rules. As a scientist, he could stop there; these rules could be used to facilitate studying the phenomenon of the interaction of the human being with his/her environment. Instead, he takes a step further: he uses the rules to formulate algorithms on which architectural design could be based to achieve optimum results. This may sound restrictive at first; and yet it is not. The "restrictiveness" of the algorithm depends on the complexity of its implementation. In a highly complex application, an algorithm does not give pre-determined results, it just avoids pre-determined errors. And, as the algorithms are based on observations about the interactions between human beings and their environment, this approach is in fact working from the bottom up. Fully aware that buildings are basically meant to serve their inhabitants' needs, he argues that the current architectural situation is the equivalent of a very large-scale experiment on humans. An experiment that is not only inhumane — because it is not biophilic — but also scientifically flawed: for, unlike biomedical experiments, it is conducted without appropriate controls and without any feedback.

Through an elegant analysis, Salingaros shows how the information load, and also the way that this information is ordered and structured, is essential to the biophilic character of a building. There is no wonder why Art Deco, although modern in a sense, is infinitely more interesting than what followed: it simplifies decorative details, it makes them more rigid and geometrical, but it does not abolish them altogether. Some "information load" is lacking on a three-dimensional level, compared to older styles (even to its immediate predecessor Art Nouveau), but it makes up for it, to some extent, by its choice and use of materials such as marble, which is rich in information content on two dimensions.

It seems that modernist buildings in the International Style actually look better when they are viewed on a large scale. A single storey modernist building may have no detail at all in more than one or two scale levels; a 20-storey modernist building might inevitably have more scale levels: the building scale, the storey scale, the window (or lattice of curtain-wall) scale. Structural details will give it some extra scaling, making it more pleasing to the eye than a small building of the same style, for reasons not related to the architect's intentions; however, its lack of ordered scaling and complexity below 2-3 levels makes it, at a glance, much less satisfying to look at than a pre-modernist building. A building such as this lacks scaling coherence and is, in fact, informationally collapsible: all of the building can be reconstructed by simple repetitions of one simple unit. Deconstructivist and postmodern buildings also lack scaling coherence, but for different reasons. Drawing conclusions from biology and elementary particle physics, Salingaros demonstrates how such buildings, in effect, lack "life", which is an emergent property of matter and energy that requires certain degrees of hierarchical complexity.

In an era when often cloudy "new age" approaches are presented as an antidote to mechanization, the work of Nikos Salingaros demonstrates how a new approach is possible through the scientific method: wholism through careful dissection, and then re-application of all the parameters involved.

Trying to follow the arguments of modernist architects often feels like ice-skating: it can be pleasant, but one has the eerie feeling that one's feet are not firmly on the ground. Reading Nikos Salingaros' writings seems to have the opposite effect: readers are reassured that their "gut feeling" should not be frowned upon and ignored, that what one likes and dislikes is not irrelevant, but that it can in fact be systematically analyzed and used for constructing better buildings and a better future for humanity.

AUTHOR'S INTRODUCTION

«Αυτό που με ενδιαφέρει απολύτως — και θα έπρεπε να ενδιαφέρη όλους — είναι ότι η Νέα Πόλις θα ολοκληρωθή, θα γίνη. Όχι βεβαίως από αρχιτέκτωνας και πολεοδόμους οιηματίας, που ασφαλώς πιστέυουν, οι καημένοι, ότι μπορούν αυτοί τους βίους των ανθρώπων εκ των προτέρων να ρυθμίζουν και το μέλλον της ανθρωπότητος, με χάρακες, με υποδεκάμετρα, γωνίες και «ταυ», μέσα στα σχέδια της φιλαυτίας των, ναρκισσευόμενοι (μαρξιστικά, φασιστικά ή αστικά), πνίγοντες και πνιγόμενοι, να κανονίζουν.» — Ανδρέας Εμπειρίκος, «Όχι Μπραζίλια μα Οκτάνα».

"What interests me absolutely — and which should interest everyone — is that the New City will be realized, it will be built. Of course, not by arrogant architects and urbanists, who, stifling and stifled in plans of their own conceit and acting narcissistically (whether in a Marxist, fascist, or bourgeois manner), certainly and pitifully believe that they can arrange people's lives beforehand and regulate the future of humanity using rulers, measurements, triangles, and T-squares." — Andreas Embirikos, "Not Brasilia but Octana".

I'm pleased to present this series of lecture notes to architecture students and young architects. Ever since videotaping a presentation of twelve lectures on my own conception of the theoretical foundations of architecture and urbanism, I have had numerous requests to make the lecture notes available. The reason is that, although the lecture videos are posted freely on the Web, some students around the world with poor internet connections find it difficult to follow them, and would like to have a printed copy of the material in a handy format. I naturally proposed to my editor that these lecture notes be transformed into a proper book, but he discouraged me, saying that: "The notes have a compactness that would be lost if they were replaced by dense theoretical text, and they are much easier to follow

now. Anyway, students will learn directly from the explanatory figures." Or perhaps he was afraid that the book would grow to become too thick for the market.

And so I limited myself to inserting explanatory paragraphs throughout the text, wherever those friends who reviewed the lecture notes felt that some additional discussion would be helpful. I listened again to the original video lectures and noted those points where I gave some extemporaneous explanations, and that material is now included in the explanatory paragraphs. On the other hand, as my friend and colleague Kenneth Masden pointed out, each section of every chapter could be expanded into a separate course with additional details and explanation, so for him it's great that so much information is presented here in compact form. Masden feels that the present format gives an opportunity to whoever is teaching a studio or theory course to assign this book and to provide the details, and thus a way to get the instructor involved in interpreting the results.

I am not so optimistic, since most if not all of the material presented here lies outside contemporary architectural education and practice. Architecture lacks a common established tradition of knowledge that would make it easy to correctly interpret my notes. Worse than that, many instructors either teach design rules that are the opposite of those I present in these lectures, or they mistakenly (and arrogantly) believe they already know everything of value, and thus dismiss all of this material as unnecessary. Despite these obstacles, a large number of young people around the world have found in my work an invaluable source for learning about what architecture really is, and also the tools for building the "New City": a living environment on the human scale. In the end, this book will probably find a use for learning outside the present system of architectural education, and that may be its role in shaping the architects of the future.

Architecture and urbanism are formulated here as applications of computations. By applying cutting-edge mathematical techniques to architectural and urban design, a new toolbox is presented to design practitioners. Each step in the design process, on every scale, corresponds to a computation. This series of lectures brings together geometrical constructs such as Cellular Automata, recursive growth, the Fibonacci sequence, fractals, universal scaling, etc. Few of these topics are currently taught in architecture schools, nor are simple descriptions available for non-mathematicians. All of these disparate techniques are woven together into one useful design tool, which can be used by both architecture students and practitioners. The design methodology combines structural rules with a free design/computational method that liberates a designer from any previously held design dogma.

Complex systems and computational reducibility are frameworks that help to formulate the basis for a general theory of design, by understanding the algorithmic complexity of the design process. The theory of intelligence and memory storage is intimately tied to interactive computations. Concepts from biology such as morphogenesis, the evolution of structural features, and embryonic development are applied to architectural and urban design. There are remarkable instances of how these techniques generate natural forms such as plants, seashells, and other organisms, and those can be successfully transferred to create the built environment. Evolutionary regression is also essential in understanding the historical

drift of architectural styles. Architectural viruses play an important though negative role by erasing traditional form languages.

Christopher Alexander's most recent work is highlighted and explained with simple examples. The computations necessary for design decisions have to follow a very specific sequence; otherwise the end-result will be dysfunctional. Alexander's classic work on "Pattern Languages" is an essential part of adaptive design, since Alexandrine patterns provide essential constraints on every adaptive computation, without which buildings or urban regions becomes uninhabitable. Results from theoretical physics delve deeply into the concept of symmetry. Using elementary particle symmetries to better understand the process of symmetry breaking reveals how to create "energy" in architecture through the use of ornament. It is shown how indigenous design, such as is practiced in building favelas, bears a striking parallel with the mechanism by which mobile robots function.

On the urban scale, New Urbanist codes should finally replace the post World-War II zoning that created cities fit only for cars. The regeneration of cities and suburbs depends upon the type of urban computations that are described here. Tall buildings come in for severe criticism as not offering any true energy benefit, but many hidden costs: they are neither the solution towards achieving urban density, nor to creating green urban regions. The correct manner to designing a sustainable urban plaza is outlined. In so many cases today, a "sculptural" conception of the city destroys urban life because it is completely foreign to human scale, movement, and interactions. It is time to recognize that much of what is now being built around the world (by prize-winning architects) is dysfunctional and unsustainable. The scientific results presented here clearly differentiate what works from what doesn't.

PREFACE

GEORGE PAPANIKOLAOU

I came away from reading this book especially informed and much more optimistic. This rarely happens these days… I would like to note my personal impressions and all the thoughts that were generated in someone who comes from an entirely different discipline.

Before coming into contact with this book, I would have looked with special mistrust at anybody who claimed that architecture could be ranked among the sciences. Even more so, as the criterion of what constitutes a good and successful design seemed to be lost in labyrinthine conversations among experts. This book reminds us of the obvious starting point that in the final analysis, successful works are those that are used, loved by their residents, and which help them

to develop all those activities and emotions that make their users more human. This reflection locates architecture in its true calling, a mission that is deeply human-centered.

We work, we fall in love, we cook, we meet, we communicate, and raise our children (only to mention for example a minimal number of different functions and human needs) within a space that we actively construct and shape, but which in turn shapes us. It either offers us or it removes possibilities. If one thinks about it, this multiplicity of needs that have to be satisfied simultaneously and to coexist harmoniously inside living space is by no means smaller than what we meet in nature, in ecosystems, or in the organization of multi-cellular organisms. Therefore, the magnitude of the challenge posed by architecture and urbanism is not inferior to the other sciences such as the life sciences.

In those sciences, we have finally learned after a series of mistakes, faulty theories and methodologies that complex phenomena cannot be grasped and cannot be explained, nor do they lead to viable applications that come from the ideas of some inspired geniuses. Rather, insight comes from a laborious and collective effort in which everyone collaborates with his/her own building stone in building up the edifice of common knowledge. In the field of genetics, pioneering methods of organizing scientific work through collaboration were applied in the past few decades in an innovative manner, within the framework of a world-wide scientific society using methodologies, algorithmic methods of computation and knowledge sources open to all researchers, with the result that we achieved great and complex works such as reading the human genome. The modern model of a successful scientist in our discipline (and I don't yet include Medicine, which lags with a constant delay) tends to be modest, and to increasingly refer to individuals who managed to organize a collaborative effort with an inspired method. Why should an architect constitute an exception to this?

Work of such complexity as architectural and urban design has to benefit from the methodological achievements of the other sciences. Partitioning the problem into smaller parts, analyzing those parts, creating smaller organized constituents that can be tried out experimentally so that their possible errors can be fixed, the use of basic rules for re-composing the whole again, utilizing human intuition as a subconscious computing resource that incorporates both knowledge and practice, organizing the participation of many partners for the success of complex works that can neither be conceived nor constructed by isolated individuals — these are some of the contemporary practices that this book incorporates into architectural theory.

The city is not simply a human ecosystem but an organized system that has to be made to fit harmonically inside the natural ecosystem if it wishes to be viable. The challenge is great.

The book's criticism of modernism occurs on many levels and is justified. It should not be perceived only as a polemic, but as a tool to show new directions by means of demonstrating the difference with the old (modernist) ones. The difference is in fact significant and systematic and is slowly dawning at the appropriate

historical moment. Looking back, architecture and urbanism is only one sphere of the modern age's expressions of misfortunes. Analogies exist in almost all sectors of human endeavor, as for example the catastrophic exhaustion of natural resources and biodiversity. Facing the darkness of the threatened catastrophe, the beginning of a period of arduous re-arrangements, political instability, and growing unhappiness, we can understand as a species how foolishly we have behaved up until now. Is this however enough? No. A German philosopher said that the problem with the world is that we need to change it. In order to do that, we require well-established scientific ideas and practical directions for action. And it is this that makes this book especially integrated. It does not limit itself to reviewing all the basic rules, it does not restrict itself to criticism, but it reminds us of the objective — which is to serve humankind — and it shows us the methodology and organizational forms upon which we can rely in order to try and achieve this goal. This is a virtue that one rarely finds nowadays in a theoretical treatise. It is an invitation towards building a living human ecosystem.

Seldom does one have the good fortune to read an educational book of such clarity and directness. More than that, however, it is an educational book that opens wide the reader's horizons and helps him/her to see the analogies and internal affinities with other sciences, embodying their most important successes into architectural theory. I believe that this book crystallizes a historical necessity (and if it were not written by this author, it would have had to be written sooner or later by someone else). There is a need for architectural theory to be founded once again upon a scientific foundation that will allow it to fulfill its new historical duty: the creation of a new living world. For this reason I believe that this book's ideas will grow stronger in the domain of architecture with the coming years, they will be discussed, and will constitute the embryo for the architecture of the future. Justly, therefore, it is titled "the future of architectural theory". As for its author, he is simply carrying out his historical duty.

As a result of the breadth of its discussion, this book stimulated many thoughts having to do with the historical development of the sciences. I believe that our own sciences also followed a parallel path and discovered their present-day self by following an analogous sequence of steps to those of architecture. I think that the reversal of the presently established situation is unavoidable, and time is on the author's side.

LECTURE 1:
COMPLEXITY AND SCALING.

1.1. RECURSION AND THE FIBONACCI SEQUENCE.

1.2. UNIVERSAL SCALING.

1.3. BIOPHILIA.

1.4. SCALING FROM DIVISION.

1.5. COMBINATORIAL COMPLEXITY.

1.1. RECURSION AND THE FIBONACCI SEQUENCE.

ALGORITHMIC DESIGN

» An algorithm is a set of instructions that can be followed to achieve a desired, but not always pre-determined end result
» Goes through successive states
» Breaks up the problem into smaller steps
» Sometimes uses recursive feedback
» Contrast with a conception of "all at once"

In a simple system, an algorithm computes a result through a sequence of operations, and leads to a straightforward result just like an arithmetic computation in a calculator. In a complex system, however, there could be many related results that satisfy the required conditions, so there is no single unique result. The algorithm in a complex case (for example, architecture) has to break up the problem into smaller steps. This decomposition helps to cut down the choices so as to avoid the infinite number of non-desirable states, and to zero in on the much smaller number of acceptable results. Using some hypothetical numbers, say, we wish to comprehend the complexity of a problem that presents 100,000 possible states and to reach towards the 10 desirable results that are more-or-less optimal.

DESIGN AS COMPUTATION

» We use algorithms to compute a result
» In the absence of an algorithm, we retrieve a result from memory — such computation is therefore based on what is stored in memory
» In architecture, memory of typology influences the results of new designs
» An algorithm makes us independent of memory, hence more creative

SUSTAINABLE DESIGN

» Use morphogenetic rules that nature follows
» Mimic but not copy physical, and especially biological structures
» The limitations of natural materials constrain built forms to certain geometries
» Sticking on a solar panel does not connect to the intrinsic geometry of nature!

A "morphogenetic" rule is a prescription for obtaining a form (from the Greek word morphe) via some sort of genetic information. Working within this approach to design, we seek simple rules that generate complex forms out of many steps rather than having the form specified all at once. This is the way

that biology works to build the bodies of living organisms: coded information is applied to assemble chemical elements into a very complex form that is alive.

ARITHMETIC RECURSION

» A repeated operation with feedback
» Fibonacci sequence:
» Start with the number 1, then add 1
» Continue adding the previous two numbers to obtain the infinite sequence
» 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, …

UNIVERSAL SCALING HIERARCHY

» We already have the mathematical tools for a fundamental result in architecture
» **"The alternate terms of the Fibonacci sequence are a check for subdivisions in an adaptive design"**
» **{1, 3, 8, 21, 55, 144, 377, 987, 2584, … }**

APPLICATIONS TO DESIGN. (I) GOING UP IN SCALE

» Take the smallest built scale, e.g. a step (has to be a certain height because of the size of human beings). Then, the next larger scale should be about 3 times that step, the next largest scale about 8 times the step, the next scale about 21 times the step, the next scale about 55 times, etc., going up to the size of the whole building
» The design should try to avoid significant scales in-between these approximate scales

APPLICATIONS TO DESIGN. (II) GOING DOWN IN SCALE

» Take the largest built scale, e.g. the building or its main feature. The next smaller scale should be about 1/3 of the largest dimension, the next smallest about 1/8 times the largest dimension, the next 1/21 of the largest dimension, etc., going right down to the size of small details
» There should be no significant scales in-between these scales

The universal scaling rule aids us in making architectural design decisions such as "should I make this particular building component 1m or 5m large?" By checking the existing smaller and larger components that are fixed by human physiology or by other constraints on size, our decision is made much easier. This is not meant to be a straitjacket for design, as the rule is only approximate, nor does it dictate the formal geometry (unlike the modernist design vocabulary, which certainly does dictate actual forms). If the designer has

complete freedom to make elements of a building at any size, then universal scaling helps to cut down the number of possibilities and to make the design process more efficient. It also helps to make the building more harmonious, and to recover the often-neglected smaller scales from 2m down to 5mm.
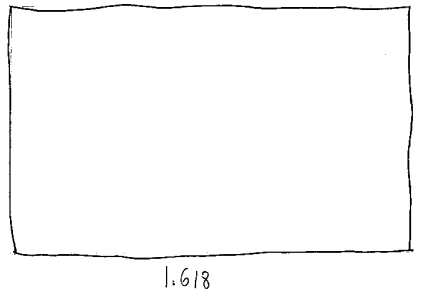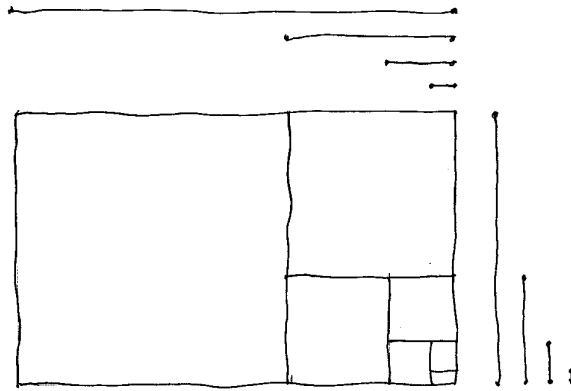
The Golden Rectangle, where $1.618 = (1+\sqrt{5})/2$
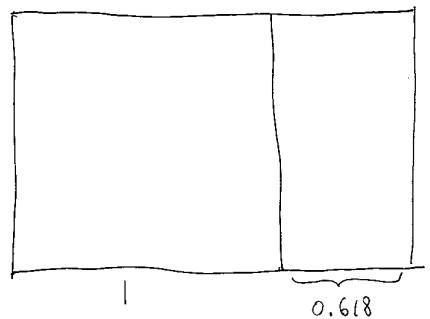
Subdividing into a square plus a vertical golden rectangle
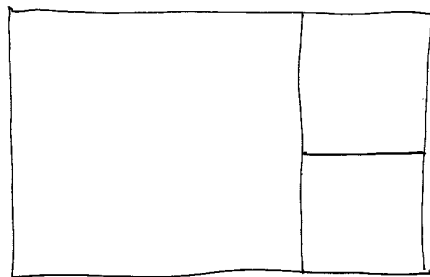
Two subdivisions generate a similar horizontal rectangle: two golden rectangles in the same direction

Universal scaling lengths

We thus generate two sequences of lengths: vertical dimensions as sides of golden rectangles, and horizontal dimensions also as sides of golden rectangles. Both sequences separately obey the universal scaling introduced above (very approximately, because the numbers we get from the golden rectangles are not the same as the scaling sequence). Nevertheless, an architect who wishes to understand universal scaling but doesn't know the Fibonacci sequence can just look at the golden rectangles and see the relative ratios between successive scales in a building that lead to design coherence. This picture also shows how we continue into smaller and smaller scales.

MATHEMATICAL SCALING RATIO

» The limit of the ratio of alternate terms of the Fibonacci sequence as the terms get large is a fixed irrational number, 2.618 = 1 + Golden Mean Φ
» Powers of 2.618 do not exactly give the integers 3, 8, 21, 55, etc. because the Fibonacci sequence is not a geometric sequence.

THE EXPONENTIAL SEQUENCE:
ANOTHER TOOL FOR UNIVERSAL SCALING

» Practical tool: use a geometric sequence of powers of the logarithmic constant $e = 2.72$, which determines the shape of animal horns, shells, etc.
» 1, $e = 2.72$, $e^2 = 7.39$, $e^3 = 20.1$, $e^4 = 54.6$, $e^5 = 148$
» This geometric sequence is approximately equal to the universal scaling sequence, and is certainly close enough to compute the scaling ratios for generating architectural subdivisions.
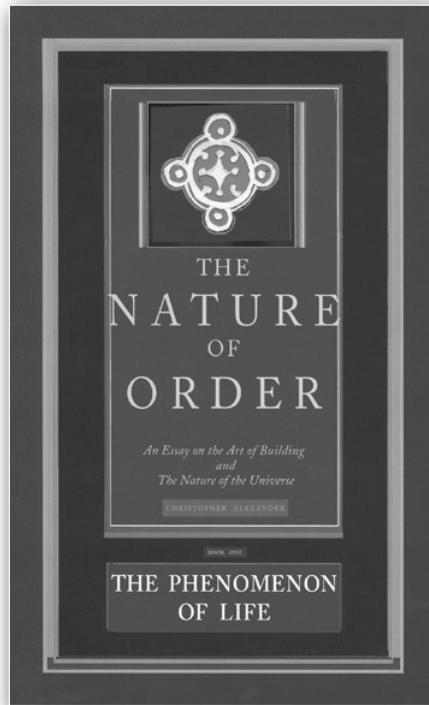
1.2. UNIVERSAL SCALING.

CONSTRAINTS

» Constraints make design easier by narrowing down choices
» There are several constraints that guide design to adapt towards innate (biologically-based) human sensibilities
» Universal scaling is a necessary but not sufficient condition for adaptive design

A constraint is a rule that specifies either an exact condition to be satisfied, or a range of parameters within which a result must occur. For example, an architectural constraint could be "the buildings has to be 17.4 meters high", or possibly "the width of the sidewalk can be anywhere from 1.2 m to 2.4 m, but no narrower and no wider". I propose a very general constraint to apply to all structures, on an architectural scale as well as an urban scale. This constraint does not refer to specific dimensions or measurements, but instead to a scaling relationship among ALL dimensions present in the design. The constraint of universal scaling applies to the approximate ratio between any two successive scales as defined by the components of a structure. This constraint is meant to apply independently to the lengths and widths of built components, and I claim that a design is better adapted to human sensibilities if it satisfies this constraint.
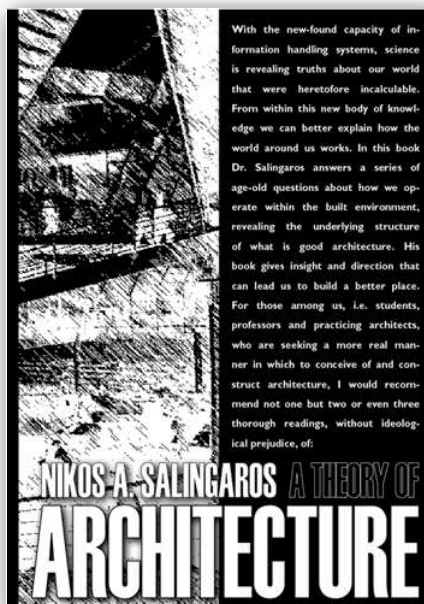
UNIVERSAL SCALING HIERARCHY

» Extends the old "Rule of 3" used in the past, by giving all the other terms
» See "A Theory of Architecture", Umbau-Verlag, Solingen, Germany, 2006: Chapters 2 & 3.
» Develops earlier results by Christopher Alexander in "The Nature of Order, Book 1", Center for Environmental Structure, Berkeley, California, 2001.

The "Rule of 3" is sometimes found in historical (ancient or medieval) building manuals in statements such as this: "make sure that there is something three times what you are building, and also something that is one-third the size of what you are building". I am referring to a rule of thumb that has long ago dropped out of the common architectural conscience. In truth, nothing like this survived into the twentieth century, so several generations of architects have no knowledge of it.

Christopher Alexander's „The Nature of Order, Book I"


„A Theory of Architecture"

THE GOLDEN MEAN

» It so happens that universal scaling is related to the square of the golden mean Φ
» $\Phi^2 = \Phi + 1 = 2.618$
» This interesting coincidence has nothing to do with the proportions of rectangles, such as credit cards, the carefully-chosen front elevation of the Parthenon, and other buildings!

....

Note *an essential difference in our approach: the Golden Mean is traditionally applied to rectangles, whereas here I'm talking about a sequence of lengths that have nothing particularly to do with rectangles. In a rectangle, one compares its width with its length, which is irrelevant for universal scaling; I measure dimensions of architectural components in the same direction, and compute the relative ratios between successive scales. In addition, many of the famous examples of the Golden Mean to architecture have to be carefully chosen to come out right (does one include the Parthenon's triangular pediment and the steps or not?).*

....

ARCHITECTURES THAT OBEY UNIVERSAL SCALING

» Gothic Architecture
» Classical Western Architecture
» Islamic Architecture
» Vernacular architectures the world over
» Traditional architectures from all cultures and all periods
» NOT international modernism

$$\frac{a}{b} \approx 2.47$$

$$\frac{c}{d} \approx 2.48$$
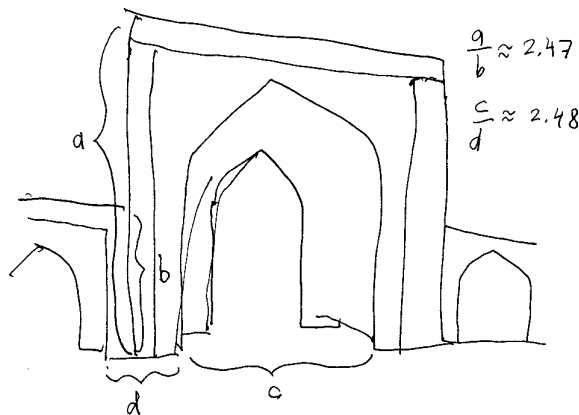
Masjid-i-Shah, Isfahan

Alhambra, Granada

$$\frac{a}{b} \approx 2.75$$
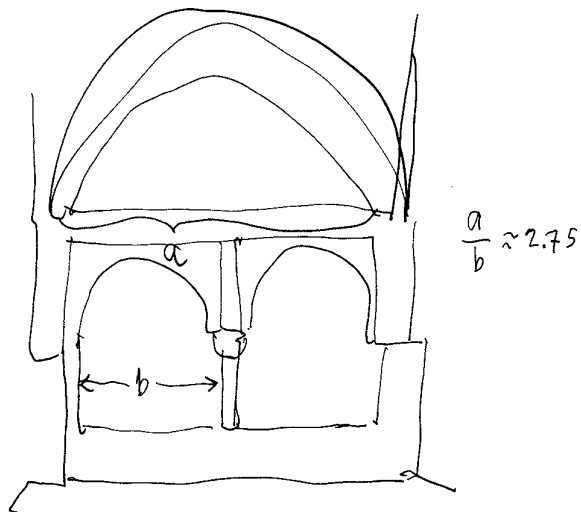
## VALIDATION FROM EVOLUTION

» All the cultures we know evolved universal scaling in their indigenous architectures, both vernacular and monumental
» Universal scaling is therefore innate
» The exceptions are military fortifications and the Pyramids, which had to appear unapproachable from the outside
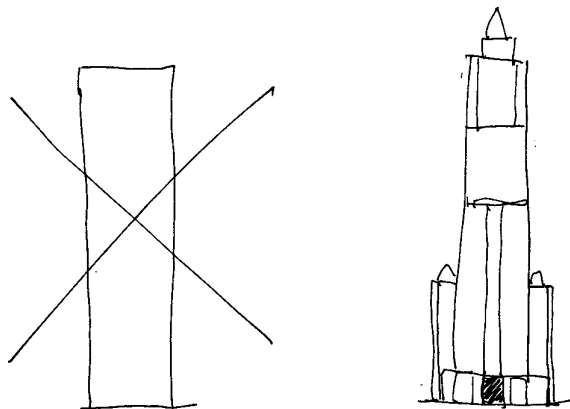
Application to skyscrapers: the glass-and-steel box versus an early Art-Deco skyscraper
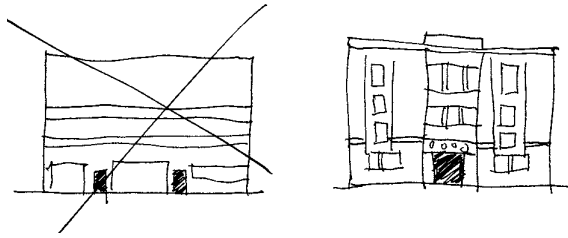
Application to house façades: two residential buildings of similar size, Modernist versus Art Deco

THE SMALLER SCALES

» The comparison we just did with two residences of roughly the same size and shape is seen on only the larger scales
» But it is on the smaller scales that the difference is really dramatic
» In the modernist house, there are no smaller scales, thus no scaling hierarchy
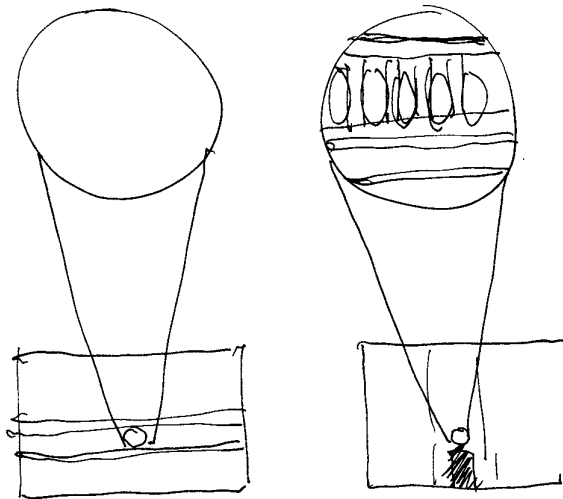
Magnification reveals the smaller scales, or their absence, in the two residential buildings shown above

I'm giving out a challenge by claiming that the vast majority of buildings all around the world before the industrial age obey universal scaling (and actually continuing into the early industrial years). This holds for all different cultures, all different periods, and is not restricted to a few carefully-selected buildings that I might refer to here. This claim can be documented by on-site measurements, and then the term "universal" becomes apparent, since it applies

to indigenous architectures, both vernacular and monumental. Universal scaling is therefore innate to how human beings create forms, and is not a feature tied to any particular culture.

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APPLICATION: WIDE BOUNDARIES

» An articulation needs its edge defined
» Commensurate with universal scaling, edges or centers should have a lip
» This gives us wide door and window frames, baseboards, pilasters
» There is no longer a need to show off industrial materials without supports

$$\frac{a}{b} \approx 2.7$$
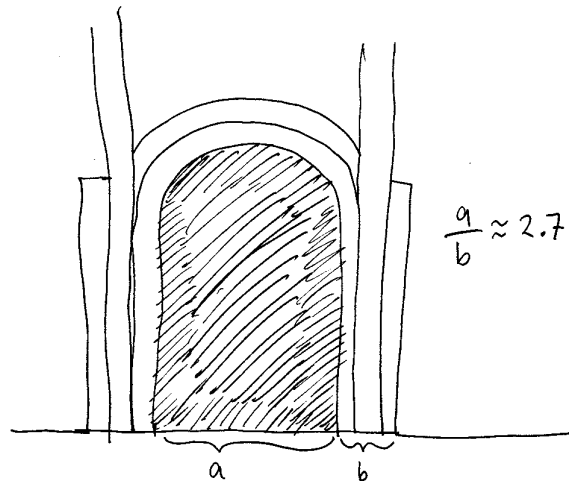
Wide door frame

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Frames *were eliminated in the 20th Century to show off the strength of new industrial materials: a door or window no longer needed a thick structural frame for strengthening. This was taken to the extreme of bringing the wall right up to the opening and smoothing out the transition, soon becoming a fetish in a minimalist expression of a door or window as a hole-in-the-wall. Few people realize that the dominant form language in use today is just a statement of bravura that has long outlived its psychologically shocking message. On the contrary, a user gets a sense of coherence and stability when confronted with a thick boundary to an opening.*

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