DESIGN PATTERNS AND LIVING ARCHITECTURE

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Introduction

This collection of articles describes how to use design patterns to create better — more emotionally-responsive and human — architectural environments. The pattern concept was introduced by Christopher Alexander and his collaborators in 1977, and has enjoyed wide success outside architectural culture. For various reasons, this design method and its accompanying philosophy of adaptation have not yet entered the architectural mainstream. Nor are design patterns taught at universities on a regular basis, since academics correctly perceive them as representing the opposite of formalistic design (and clearly privilege the second methodology).

This booklet has three rather ambitious aims:

• To educate practicing architects and the general public on why design patterns are both useful and necessary.

• To explain how the pattern method applied to the built environment contains the seeds for adaptive design.

• To establish the scientific validity for design patterns, while invalidating methods based on fashion.

A promised new era of unprecedented design innovation has as its goal to create a humane, healing environment for the user. Nevertheless, this aim conflicts with the construction industry's drive to finance self-indulgent expressions for architects' egos and personal whims. As such, this booklet is bound to generate controversy because it steps on many toes. Yet if our society wishes for a better future, it has to make a number of necessary changes.

The essays refer to scientific results that are published elsewhere in more technical language. Readers who wish for further detailed information, or to verify the claims made here, can follow up the references. The breadth and depth of this topic go far beyond visual design, to describe essential aspects of human life. Patterns are actually one small portion of a body of research by a large number of contributors spanning several decades.

Anyone eager to apply design patterns needs practical guidelines. The literature is unfortunately scanty on this topic. A book chapter reprinted here as an Appendix outlines how to use design patterns in practice. Even though design patterns were first published in 1977, they have a penetrating lesson to teach contemporary architecture. Design patterns were a remarkably prescient methodology that is only now finding its most profound expression. They contain the seeds of a new, adaptive approach to architecture.

1. The 21st Century Needs Its Own Paradigm Shift in Architecture

A cure for spatial design amnesia

For well above half a century, most new buildings delivered by architects to owners have had extremely poor spaces, both inside and out.

I blame this sad state of affairs on the criteria used for the critical evaluation of the built environment. Buildings that are expected to inspire other architects and evolve new building practices are assessed in the design media as well as in academia as the latest fashions in form. It's hard to see them as major advancements in the art and science of creating human habitation. Excited write-ups and the latest round of design awards praise buildings seemingly intended to induce the greatest level of personal anxiety by those who use them. All this merely lays the ground for the next round of psychologically debilitating places. Such failures, on the part of academic institutions and professional designers, would not have been tolerated by architects operating in any other age of human history.

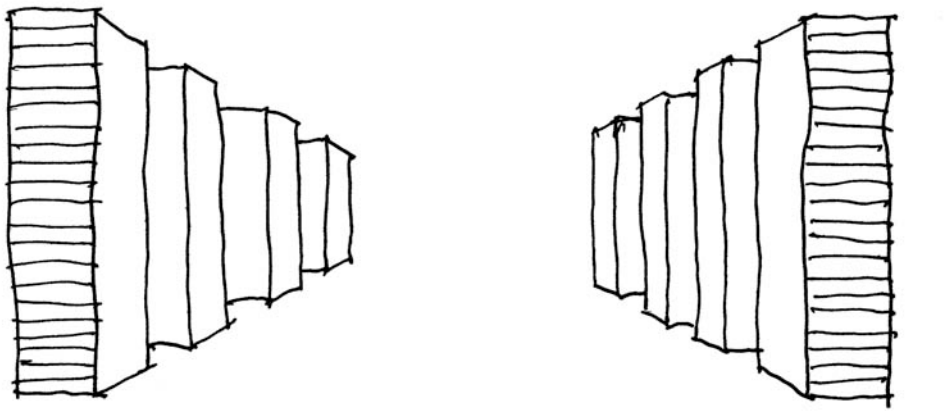

Figure 1.1. Non-adaptive double-loaded skyscraper corridor destroys urban space. Interior spaces are not much better in this energy-wasting formalistic statement.

The early 20th century paradigm shift that came with replacing traditional ways of building by modernist design methods was a wrenching experience; it replaced centuries of cultural preference for humanly adaptive spaces, and imposed on us, instead, an acceptance of psychologically damaging ones. To undo the last century's paradigm shift will be similarly traumatic for everyone involved in design and

construction today. A whole set of practices and institutions need to be dismantled: Architecture prizes awarded by august committees of practitioners, academics and critics with long resumes, distinguished patrons smiling for photos next to pasteboard images of buildings — these are easily dispensable, but no less necessary to end than the decades of professional, academic, and critical myopia that have buttressed the industry's ability to tilt the architectural playing field against a more healthy, humane way of building. The forces that validated deficient design would be, and should be, discredited in a new paradigm shift — the sooner the better.

We need to begin again from zero.

We do not merely require a new architecture. Such an objective would be immediately misinterpreted as simply a new design style. What is proposed here is the foundation of a new *kind* of architecture: an entirely novel way to think about and practice architecture, extending far beyond any superficial novelty of appearance. Triggering a new paradigm shift, one that revalues the value of living structures, won't be easy. We recognize that a new shift in the way we evaluate the built environment would be as destabilizing to today's established order as the one that occurred in the 1920s.

The 21st century solution is to re-discover and document the properties of responsive spaces that adapt naturally to human needs. Fortunately, we have tools that make this gigantic task much easier than before. The design patterns of Christopher Alexander from 40 years ago provide pieces of the solution that we can put together for a contemporary understanding of space (Alexander *et al.*, 1977). And there is an enormous amount of new material from current research that was not available back then (Mehaffy & Salingaros, 2015).

But first, what can we do to motivate a paradigm shift? We cannot turn back the clock. To misinterpret our program as merely returning to pre-war traditional architecture is a mistake. Such an error is behind the most facile and intellectually empty arguments against change, used to block progress in adaptive design. In fact, we wish to leave the non-adaptive past behind us, and jump forward to a new, adaptive architecture in which spaces and surfaces are exquisitely responsive to human biology.

This movement is both motivated and justified by modern science, and has nothing to do with fashion or design ideology. Resistance to introducing an adaptive mode of design is extremely strong, because the cultural mainstream is invested in what is, not what could be. People are frightened of abandoning conventional ways of interpreting the world, even if those ways are demonstrably false. Here, convention and familiarity trump truth and science. It has always been thus with humankind.

The need for a new language

We require a new design language to describe the proposed paradigm shift because today's design language is simply incapable of expressing the elements of "living" space. Our common language possesses neither the vocabulary nor the syntax to do so. Otherwise, we are forced to reach back to words and expressions from other topics, especially the romantic descriptions of the 19th century and beyond, to explain contemporary scientific results. That would be inaccurate and misleading. Furthermore, it risks condemning the whole effort to failure, from the beginning, because it gives the false impression that we are going back to those historical times instead of moving forward to a better future.

Already by 1977, when *A Pattern Language* was published (Alexander *et al.*, 1977), the cultural mainstream had brushed aside living space as an irrelevant concept, and for this reason it was never assimilated. Consequently, there was no need to describe it in words.

The notion that space could be "alive" was relevant only to an antique worldview, which was considered valid until the 20th century. But the mass consciousness of the population has changed radically since then. There was no one within mainstream culture who was ready to assimilate this information in 1977. Even those individuals who recognized the tremendous potential for these ideas were hesitant to adopt them, because they would have to re-organize their mental structures in order to do so, and reject common cultural assumptions. The implied hierarchical re-organization was too radical. Society was not ready to abandon comfortable ways of thought.

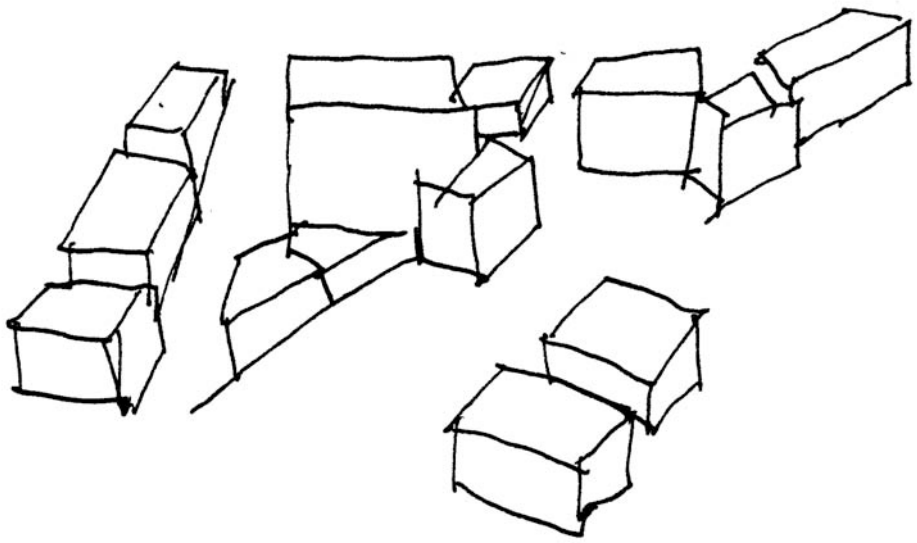

Figure 1.2. Building footprints adapt to climate, flows, and other existing buildings. Allowing each one to differ from the others helps to create usable urban space.

Is society more receptive today? I believe it is. We have become technological, and ironically, advanced technology has revealed the inadequacies of the early industrial model. It is now possible to take the language of contemporary technology, and use it to describe a new kind of architecture.

Alexander recognized the need for a new language, which he addressed in his book, *The Timeless Way of Building* (1979). In it he describes the "Quality Without A Name" — the QWAN, as it is known in computer science — which for practical purposes can, indeed, be named. It is the quality of a living environment. It describes systemic harmony, organized complexity, and coherence in our surroundings, and can be distinguished from crude mechanical principles that have dominated design in the machine age. It is present in structures that make us feel healthier whenever we are exposed to them. We receive sustenance from artifacts and settings that possess this healing property, which reflects the processes of biological reproduction and development. This healing process occurs in environments whose positive emotional quality comes from innumerable mutually reinforcing and psychologically nourishing interactions.

But this did not solve the problem. While Alexander's Zen-like treatment of the linguistic problem appealed to some — and continues to appeal to them very strongly — mainstream architects did not embrace it. And so, unfortunately, that opportunity was lost, and it was not picked up again until decades later by pragmatic computer scientists. After 20 years, with *The Nature of Order* (2001-2005), Alexander offered another solution, developed in great detail over four volumes, by introducing the concept of "wholeness" and his "theory of centers" as part of a new design vocabulary.

Designed monotony versus natural variety

Monotony and variety can apply to both the natural and the artificial environments. In our artificial or built environment are two distinct classes of object: *copied* and *generated*. A template, or set of design rules, that allows some freedom of execution generates objects; it does not copy them. A copy is literally stamped out. Designing and building in a generative process involves many steps, each of which addresses a range of factors, introducing variety, just as in nature. Variations are the result of environmental forces that differ from place to place and in the same place at different times.

In *The Nature of Order* (2001–2005), Alexander emphasizes that traditional and vernacular architecture is of this generative type. We see enormous variety and little monotony in tribal settlements, in traditional urban fabric, in historical and vernacular buildings, even in architecture designed according to rigorous classical orders of ancient pedigree. The reason is that, as a natural function of their production over and over again by humans, they adapt to the complexity of the actual conditions in place.

With industrialization, our design paradigm underwent a drastic shift: from generating form to copying form. This was the point of early mass production. Identical copies, with their supposed high degree of simplicity and low cost, became the norm and the primary objective of industrial design. But producing identical copies means isolating design from local forces — indeed, any adaptive forces. The industrial age came to insist on linear, monotonous alignment of identical copies (Salingaros, 2011). This triggered monotony as society's principal psychological reaction to the ideals of repetition and mechanical alignment.

Monotony in our environment has profound consequences on our psyche. A worldview that exalts visual monotony has taken over an earlier environment shaped by the variety of natural forms. If industrial production tied to economic growth and prosperity necessarily generates monotony, then design variety is sure to be considered a drag on the operation of our economy. Indeed, this substitution of monotony for variety now dominates our society, especially in fields that claim to exalt creativity, including architecture.

Nature certainly shows little monotony (Salingaros, 2011). This might appear surprising, since geological mechanisms follow the same basic tectonic forces to produce change — erosion, pressure, glaciation, heat, plate shift, fracture, etc. — while biological mechanisms follow the same basic organic principles to grow, reproduce, and decay. Organisms use DNA to generate copies. One would expect the results to be identical, but they are not. Everything in nature is "generated" but is, in fact, never "copied". Each example of an object or organism is created from the same design template, yet the result differs slightly each time. Individual objects and organisms differ because step-by-step generation creates small variations. Thus, the positioning on the evolutionary timeline of each natural entity, be it a rock formation or a salamander, is always complex, never monotonous.

2. Architecture For People, Not Machines

How machines differ from organisms

Throughout their lives, people are continually exposed to entirely distinct types of architectural experiences. Explaining the difference comes down to the contrast between the machine and the organism; these definitions are crucial for understanding and judging architecture (Salingaros & Masden, 2008; 2015).

The crucial distinction between machines and organisms goes far beyond architecture, of course, and is nicely clarified in the "Santiago School of Cognition" (Hallowell, 2009). Let me summarize this important work by Humberto Maturana and Francisco Varela here.

First, organisms evolve in a competitive and hostile natural setting. A living organism is defined as a fairly self-contained entity that possesses mechanisms for responding and adapting to its environment. Biological forces continuously triggered by environmental factors help keep the organism alive, and determine the living system's behavior. A mobile organism decides where to move and where to stay, using an exquisitely developed sensory system to navigate its surroundings. Recurring physical situations that enhance the organism's life define its living patterns: the organism will seek those out of instinct. Conversely, the absence of living patterns puts an organism on alert.

The organism senses external agents that influence its environment and could interfere with the organism's natural response-driven choices. Any departure from living patterns triggers survival mechanisms. Forcing an organism to deviate from its innate living patterns only results in disturbing the organism's natural complex functions and actions. It reacts to our interventions in unexpected ways — unexpected, yet perfectly logical according to the organism's own program for survival. We might think that an animal or person would love cantilevered overhangs, for example, yet those create alarm if you are underneath them. Our design choices change the dynamics of the living structures the environment contains, in ways we need to understand.

Figure 2.1. Traditional corridors employ natural light and numerous, visually-interesting patterns to create a healing environment, giving us a positive feeling: "This space is so nice that I should spend some time here instead of just walking through."

In contrast to an organism, which responds to stimuli and thus is difficult to control, a simple machine or inanimate entity is entirely subject to control from external agents. It can be molded or changed in many different ways: it has no intrinsic patterns that it prefers or falls back on. With rare exceptions, a machine does not interact with its environment, and so transforming its immediate setting has no effect.

Designing for organisms vs. machines

Designing for organisms is challenging: in adaptive design, we cannot control intrinsic biological needs and sensitivities to the environment. We need to first discover the organism's repertoire of living patterns, and then develop design rules for achieving them in practice. We must gather primary feedback in order to shape an accommodating environment and determine whether a building adapts to its users. Discoverable tools, such as design patterns, must be filed away and used to help identify potential reactions to design before it is even built (Alexander *et al.*, 1977). It's up to the designer to anticipate a user's negative and positive responses.

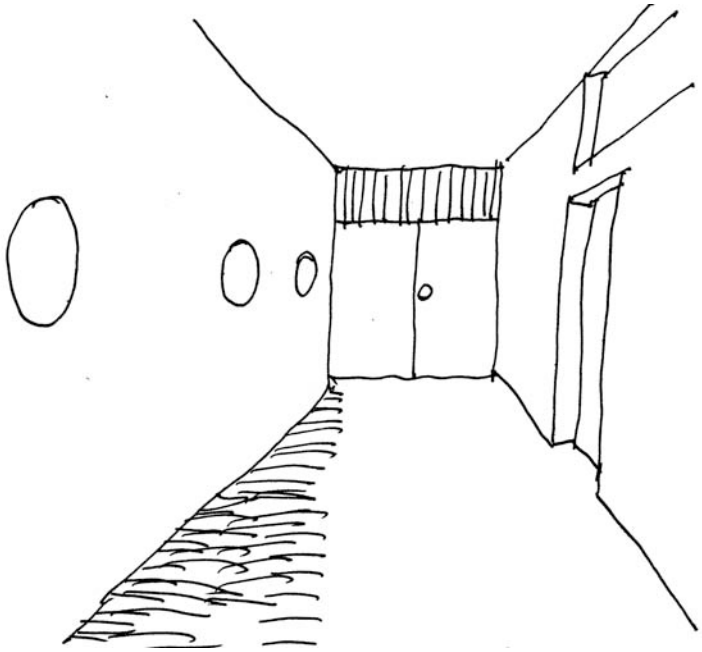

Figure 2.2. Corridor built according to the logic of the machine affects human users by generating negative emotions: "This space is dreary and depressing; I need to pass through it as quickly as possible."

In comparison, designing for machines is easy: this is the industrial approach to form. Design thinking focuses primarily on cost, efficiency, and materials. It requires no feedback. The architect quickly invents whatever shapes, spaces, and surfaces are minimally sufficient for what one wants the machine to do, or what one thinks the machine should be doing, and this is built without any questioning or testing. It's safest just to copy previous industrial typologies. Efficiency suppresses emergence, lacks awareness of living structure, and certainly does not admit living patterns into the design process.

The contemporary built environment tends to be dominated by monotonous repetition of industrial typologies, interspersed with unique singular forms, yet neither follows any adaptive logic. These pervasive practices represent the antitheses of responsive environments anchored on living patterns. We create machines but not organisms.

Following Maturana and Varela, design decisions come down to interference and control versus feedback and learning. Does one wish to dominate the environment and all it contains, or to acknowledge, respect, and accommodate its living patterns? If we choose the latter, then we have to document and interpret the effects that interventions in the built environment have on humans and nature. Our design goal is then to support, through a material framework, the natural patterns of living structure.

3. Living Structures Should Come From Living Patterns

What is a living pattern?

Patterns describe essential relationships among the elements of systems, and provide a unique and useful tool for handling and organizing complexity. This truth, embodied for centuries in the practice of creating human habitation, has in recent years been dissected and catalogued by science. Computer researchers have adopted the pattern method both to understand and to manipulate complexity. Advances in our knowledge of how patterns reflect the ordered complexity of nature has led to breakthroughs in computer technology that continue to fuel economic growth and development not just in industry but in every realm of our society (Leitner, 2015; Mehaffy & Salingaros, 2015).

Patterns of behavior, and of practice in any field of human endeavor, evolve over time with constant repetition, each repetition embedded in and learning from its predecessors. Any pattern arising from such evolutionary selection over generations is irreducible; that is, it cannot be understood in terms of simpler components. It is not a multiplication of a prior component but an accretion to its complexity. It grows ever more subtle, ever more useful, and comes closer and closer to reflecting how nature works: It is a living pattern. Such a pattern can be combined with others into a system that reflects an ever-higher level of useful relationships (Salingaros, 2005: Chapter 8).

We rely on techniques akin to genetic programming to discover evolved solutions as general methods for manipulating complexity without destroying its order. By examining an enormous number of possible small variations, a pattern is selected as the optimal configuration, the one that provides the most useful feedback. Direct simulated evolution is computationally very intensive, so the results, once obtained, are worth documenting in a pattern format.

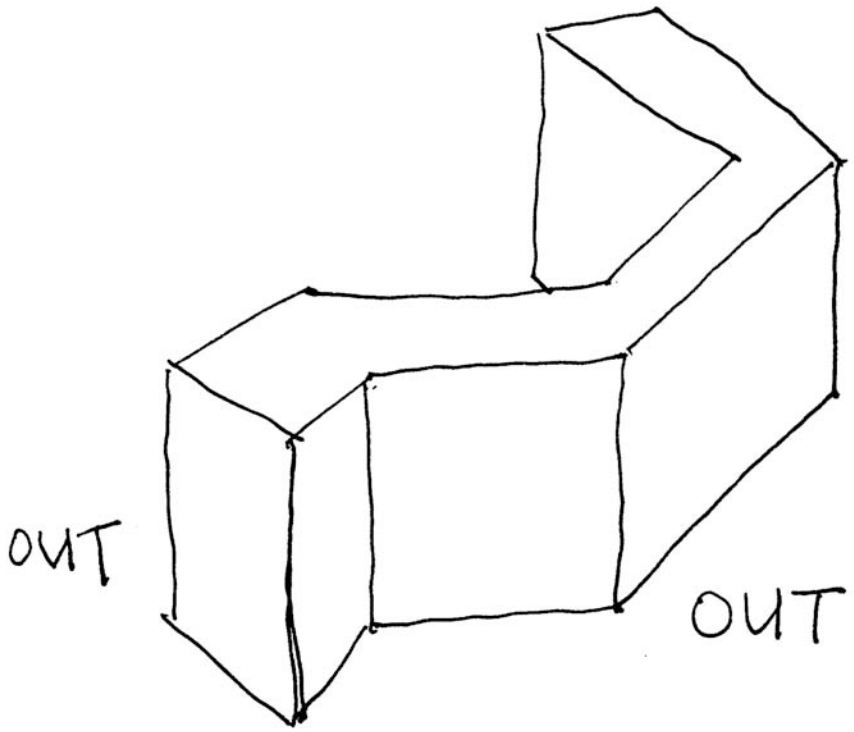

Figure 3.1. Space that exists "out there" will be used only reluctantly by human beings, because of deep psychological reasons. Contrary to what one hears and reads today about the spaces of "modernity" and "post-modernity", there are still only two types of urban space: human versus inhuman.

Twelve living patterns help define human spaces

The key question in architecture is how to design a space that feels reassuring on at least an unconscious level. Incredibly, we have been producing hostile, anxiety-inducing spaces or dreary, depressing spaces for decades, at least as judged by their users. A dozen living patterns selected from Christopher Alexander's *A Pattern Language* (Alexander *et al.*, 1977) can help architects get beyond this deplorable practice. The following pattern summaries are my own, and they focus on spatial aspects. The reader is urged to consult the original, lengthier version of each numbered pattern, which includes research material giving detailed arguments and/or scientific validation for the patterns.

Table 1. Twelve living patterns for space:

Pattern 61: Small Public Squares. Build public squares with a width of approximately 60 feet. Their length can vary. The walls enclosing the space, whether partially or wholly surrounding it, should make us feel as if we are in a large open public room.

Pattern 106: Positive Outdoor Space. The built structures partially surrounding an outdoor space, be it rectangular or circular, must define, in its wall elements, a concave perimeter boundary, making the space itself convex overall.

Pattern 115: Courtyards Which Live. The best courtyards have many entry points, a view to the streets beyond, and enclosing walls that are fenestrated, not blank. These are used most often.

Pattern 124: Activity Pockets. The success of urban space depends on what can occur along its boundaries. A space will be lively only if there are pockets of activity all around its inner edges.

Pattern 167: Six-Foot Balcony. The minimum depth of social space for a balcony is six feet, preferably with its space partly enclosed, either canopied, protected from nearby observers by side screens, or partly recessed into the facade. Recessed balconies provide an excellent sense of enclosure. But if balconies are narrower than six feet (going out), are totally exposed or entirely cantilevered, they are rarely used.

Pattern 179: Alcoves. To heighten the sense of intimacy indoors, build a useful smaller space within a larger space, partially enclosed with concave boundaries and a lower ceiling. Its width and depth could both be approximately six feet.

Pattern 180: Window Place. A concave boundary can incorporate windows. Examples range from (small) a window seat where the wall is deepened to create a space around the window, to (medium) a bay window where windows wrap around an extruded portion of the space, to (large) a glazed alcove where windows partially wrap around a room.

Pattern 183: Workspace Enclosure. The best place for working has no more than 50 to 75 percent of its perimeter enclosed by walls or windows. A workspace needs at least 60 square feet of floor area for each person.

Pattern 188: Bed Alcove. Give the bed its own partial enclosure. The space should feel comfortable, not too small, with a lower ceiling than the main part of the bedroom.

Pattern 190: Ceiling Height Variety. Give a building's rooms different ceiling heights to enhance comfort at every scale of activity. High ceilings contribute to formality, low ceilings to informality, with the lowest height for the greater intimacy of alcoves.

Pattern 191: The Shape of Indoor Space. Indoor space should be roughly rectangular in plan with straight, vertical walls for practicality, but with concave

wall portions where possible, and a roughly symmetrical vaulted ceiling. One-sided, sloped ceilings and sharp, slanted, or re-entrant angles in walls generate discomfort.

Pattern 203: Child Caves. Create small "cave-like" spaces in a house, or outside, for children to experience and play in.

Reading these living patterns should evoke a sense of human space that envelops and nourishes us; it goes far beyond strict mechanical utility. This is a primal, biological sense of space, freed from often-irrelevant architectural accretions. It is what architects have long sought, but few have actually grasped. The hard, empirical facts encoded in patterns nonetheless lead us towards understanding the elusive properties of "living" spaces, which exist on a higher level than we are used to thinking about.

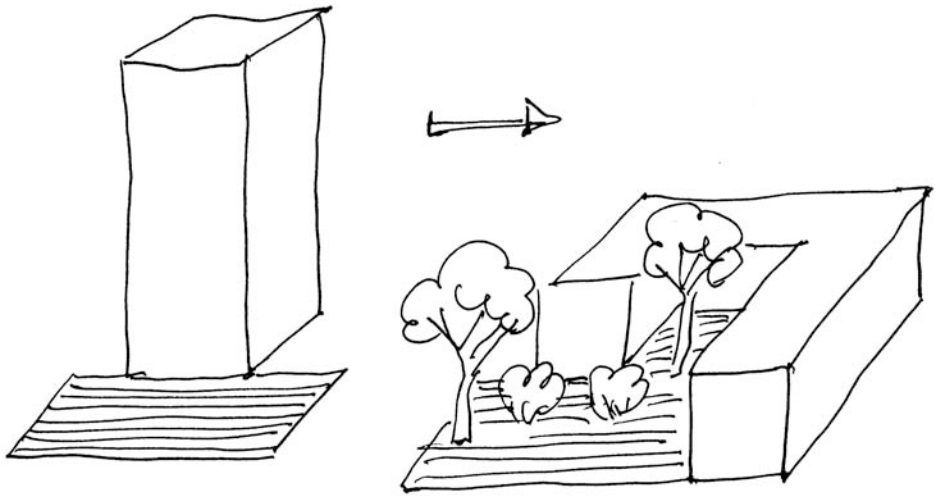

Figure 3.2. Morphing a tall building's footprint and shape to create a semi-enclosed urban space saves what was psychologically unusable exterior space. The usable interior volume nevertheless remains the same.

Recurring themes run throughout the above spatial pattern summaries, such as partial enclosure balanced between too little and too much, and the need for concave boundaries to create convex space — Alexander called it "positive" space. We need a new methodology for adaptive design, to re-awaken our lost spatial sensitivity and focus once again on creating "reassuring" spaces. These are vital for health and comfort in the built environment. If an architect expresses repulsion at the supposed "sentimentality" of these patterns, that is merely evidence of ideological conditioning to reject healing spaces.

Closely related to biophilic design patterns, spatial design patterns also enjoy scientific support (Browning *et al.*, 2014; Kellert *et al.*, 2008; Ryan *et al.*, 2014; Salingaros, 2015). First, the inherited memory from our ancestral evolutionary environment certainly includes clearings, tree canopies, and caves as prototypes. Those settings provided a reassuring sense of enclosure at the right dimension. Second, neurological responses that were developed for our general survival long ago act now to interpret a space's geometry as either friendly or hostile. Adaptive design relies on these two qualities of what made us human.

4. How do we create healing spaces?

Space can liberate us from stress

An environment that embodies living structure allows us to live life fully. We are encouraged, not inhibited by architecture. Freed from anxiety and feelings of unease induced by hostile buildings, spaces, and surfaces, our positive emotions blossom in our subconscious.

A building designed with sufficient attention paid to the natural rhythms of human neurobiology can result in conscious joy. Think of how the tectonics of the human body, our physical appearance, can trigger sexual excitement — or not. There are many examples of physical form, properly attuned to natural structure that can evoke a human response everywhere along the continuum of conscious to subconscious emotion (Salingaros, 2015).

Christopher Alexander and others have put considerable effort into cataloguing design patterns that resonate with and actualize our humanity (Alexander *et al.*, 1977). Living patterns free us from environmental stresses, which come from an incoherent geometry of objects and spaces. Architecture's capacity to protect us from stress liberates us to be more fully human, and keeps us healthy in the long term.

Figure 4.1. A traditional courtyard is full of overlapping living patterns. Those combined give the subliminal message: "Linger here for pure enjoyment, and use this setting to catalyze interactions with other living beings."

Living patterns underlay all successfully evolved design solutions. Generations of humans have built up their surroundings by trial and error, discovered configurations that made them feel healthy, both physiologically and psychologically. Living patterns arose through the evolution of built form, a long process of selection arising from thousands of experiments. The choice of a healthy architectural solution over other possibilities uses feedback to identify a state of increased wellbeing leading to long-term health. This process is the same as in genetic programming, where "software" evolves after millions of iterations, with variants continually selected and re-selected so the result performs the required task optimally (Leitner, 2015).

Most living patterns documented by Alexander in *A Pattern Language* (Alexander *et al.*, 1977) were derived from looking at solutions that unify the user within his or her immediate environment. Their main criterion for selection was the healing experienced when a pattern is successfully applied to identify useful limits to a design. The mind-set in which this phenomenon is recognized and appreciated considers human beings interacting with their surroundings strongly enough to affect their health. A living pattern is meaningless, however, in a mind-set that treats buildings as sculptural objects that don't naturally interact with their users or their surroundings.

Successfully evolved design solutions lie embedded in traditional architectures. The functional correctness of living patterns, considered as a set of design constraints, depends on their widespread occurrence globally. The proof is in their re-discovery among people isolated from each other in geographically separated societies. Everything else in those cultures may be totally different, but since the human body is more or less the same all over the world, socio-geometric solutions for a particular design problem ought to obey identical constraints. And they do! The sense of wellbeing generated by a living socio-geometric pattern is shared across distinct times and cultures.

Extracting patterns from observations

Since life-enhancing patterns recur in traditional buildings, some people assume that a living pattern is merely a design solution that has been used repeatedly. But that's not necessarily so. Many repeating design typologies are expedient for some purposes, but do not enhance human life in any way. A design template may be widely adopted because it's cheap or industrially efficient, or because it serves the interests of some group — but it doesn't lead to a healing environment for its users. It's not a living pattern. In fact in many cases, it could actually degrade the living qualities of the environment.

An enlightened approach to healthy design therefore requires a catalogue of tested living patterns for handy reference. Such a list would help to avoid confusing them with repeating inhuman typologies that are not alive (called "anti-patterns").

One list exists in *A Pattern Language* (Alexander *et al.*, 1977). Yet how do we document other living patterns from existing buildings and urban fabric? Extracting patterns from traditional practice and deriving totally new patterns both require sensitivity and judgment (Salingaros, 2005: Chapter 8).

Table 2. How to observe a pattern in existing design:

1. Living patterns usually work together as a group: they are rarely isolated.
2. When patterns appear in a weak form, we need to find the strongest example.
3. Patterns organize complexity and are not found in simplistic environments.

The complexity of the best, most humanly adapted living configurations, which solve more than one design problem simultaneously, is high. A setting that has positive effects on the user's wellbeing probably has several patterns working together to satisfy a combination of system dynamics (some of which are not obvious). So a researcher trying to document patterns must first disentangle them from one another. As in most scientific research, you first detect known patterns. What is left contains the new patterns. This discovery process is necessarily sequential, and cannot be achieved all at once.

Then, you may discover a set of similar but distinct solutions to a specific design problem whose common features identify them as possible living patterns. Suppose each related application shows undeniable healing effects on the user. But which particular constraint is the archetypal pattern? A choice among several variations of a common theme must be made. The optimal living pattern is the most "wonderful" — the one that works best, that gives the most healing feedback, and makes a user wish to experience its implementation as much as possible. Obviously, this living pattern will be difficult to locate. An architect must learn to identify patterns, and then design a solution that takes advantage of the mutual adaptivity arising from the ordered complexity common to living patterns.

An archetypal living pattern must deliver the strongest and most positive effect on human health and comfort for that particular circumstance. That way, it can reproduce the same healing effect when built into something new. Competing forces of expediency, fashion, short-term economy, or misguided architectural codes and zoning laws are likely to dilute a pattern in many of its applications. Finding a living pattern requires looking for the best possible built example, like a collector searching for the very finest seashell or antique coin specimen. This process of discovery presupposes experience, and a highly tuned sensitivity to healing environments.

Patterns as design constraints

Living patterns contribute to successful design solutions. But an architect cannot just pop a living pattern into a building design and expect it to work without any relation to a coherent organizing principle. Inserting living patterns into a rambling, incoherent building will not fix its rambling, incoherent design. While living patterns reinforce each other, they do need to be embedded in an interrelated web of adaptive structure. They are not a quick fix-it for bad design.

Alexander's *The Nature of Order* (Alexander, 2001-2005) correctly understands such patterns as constraints in a sophisticated system of computational design. You choose from among an infinite number of generated options that satisfy an interrelated group of patterns. All of these solutions are adaptive. The more constraints you impose, the narrower the set of good solutions. The design process may include adaptive constraints such as climate, site, orientation, interaction with the environment and surrounding structures, etc.

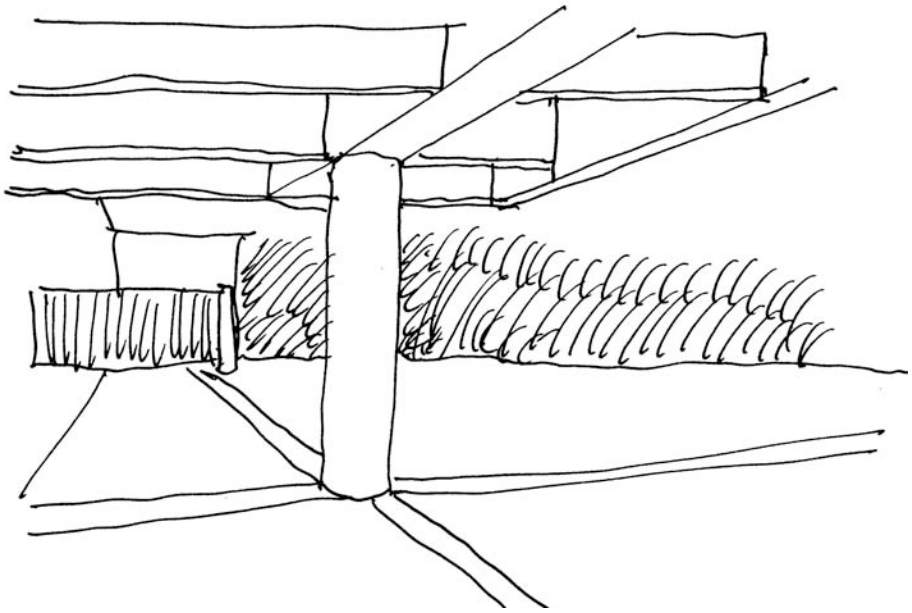

Figure 4.2. A modernist courtyard is deficient in living patterns. Its visceral message is: "Perform whatever function you have to do here – walk through, drink your coffee, talk with someone – with industrial efficiency, then get out."

Mainstream practice and training claim to reject design constraints of any sort. Architects are intoxicated with the absolute power to control human lives by determining the shape and dimensions of the spaces in which people live and work. They expect to indulge themselves freely, exerting personal will on the environment. Not surprisingly, they react to the idea of living patterns with apprehension: patterns threaten the limitless freedom to design promised in architecture school.

Nevertheless, the most paradoxical (and most embarrassing) aspect of conventional design is never mentioned. The creative freedom permitted in contemporary architecture is dictated by trendsetters, power brokers, and influential critics, and is therefore severely constrained: infinitely more than the constraints implied by living patterns. For decades architects have been allowed to create anything *except* what has the qualities of living structure. This restriction is socialized into architectural education and in media coverage of architecture. Indeed, the architect is encouraged to violate living patterns, producing buildings whose primary result is a violation of nature.

5. Living Patterns and the Principle of Concavity

Spaces that reassure our body

A well-designed space offers psychological "reassurance" to us, its users. We find such healthy characteristics predominantly in traditional places. Of course, we can perform an action in any volume barely large enough to contain it. But it should be our goal to design spaces that make us comfortable enough to enact our roles in life without feeling anxiety caused by strict geometry. A successful space, then, is shaped in such a way that it "reassures" our body and mind — not necessarily with its aesthetics, but the medical/psychological response it elicits.

We have all experienced the sense of emotional elation inside a truly great space. That elation has little to do with the room's size. Yet many Modernist architects seem strangely uninterested in the factors that are responsible for this effect. But we have evidence that the rules for designing such spaces can be discovered, and then tested. Some environments possessing modest dimensions invite us to linger there, yet other spaces of similar shape and size somehow disturb us. Some geometric components and features, which we might not notice until they are brought to our attention, make all the difference in the world to the adaptive quality of spaces that contain human activity.

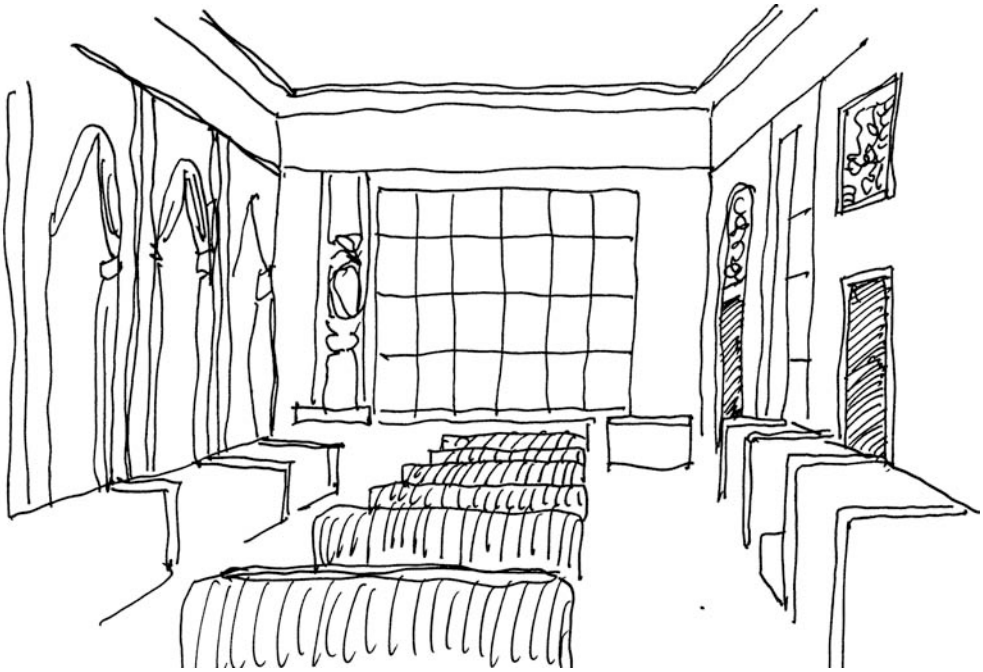

Figure 5.1. Interior of the Café Landtmann in Vienna, a favorite hangout of both Gustav Mahler and Sigmund Freud, and a wonderful space for creative conversations.

Spaces that nourish human emotions with built geometries can be documented as living patterns (Alexander *et al.*, 1977), but much of this research remains to be done. Architects trained in conventional methods tend to resist design solutions that employ living patterns. Why? Mostly because they tend to value appearance above utility. They don't want to be told that their designs might displease or even hurt users' sensibilities. That would imply failure. So they ignore feedback and insist on judging design exclusively by abstract aesthetics. For them, design patterns are anathema.

Space is experienced as positive when it is coherent

We find spaces that embrace us gently inviting. Such spaces, formed from concave boundaries, embody the "principle of concavity", which tells us that we prefer surfaces that enclose us in a more or less organic manner.

Experiments in psychology document that we have a built-in aversion to sharp objects, especially to those that point at us. Most of us prefer rounded moldings to angular moldings in window frames and sills. At the next architectural scale, walls that are not vertical and ceilings that are neither symmetric nor horizontal, and re-entrant walls and ceilings bulging towards us instead of yielding outward cause alarm. Emotional discomfort can be triggered by protruding design details meant for purely aesthetic effect — undoing real or apparent structural utility of elements such as columns, pilasters, or beams.

If we are to use urban space with pleasure and make us feel reassured, it must be partly surrounded by an enveloping perimeter. It cannot just be leftover space between stand-alone "look-at-me" buildings. In those leftover spaces, we tend to feel exposed and threatened because the nodes and paths they contain are not defined coherently (Alexander *et al.*, 1977: Pattern 106; Salingaros, 2005: Chapter 2). Such exterior space lacks internal connectivity and fails to fit into the expectations formed by our instinctive judgment of space. This expectation is built up over generations, passed down to us by previous users of the built environment as well as originating in our own experiences.

Many showcase 20th and early 21st Century buildings tend to be surrounded by lots of open space that is never used. Hard plazas and green areas designed around the buildings violate all the living patterns for urban space; therefore those areas tend to be unpopulated, hence they are wasted spaces. Sometimes vast in dimension, these spaces tend to be too open; part of them may be semi-enclosed but threatened by an overhanging roof that creates a feeling of alarm.

For decades, architectural space has been compromised by mistaken assumptions (anti-patterns). Furthermore, the industrialized world continues to

create formally striking places that skimp on essential human values. Whether cramped, splintered, or so vast as to engulf human scale, those environments are ultimately useless. The proper connected intimacy of space, offering the psychological protection essential for inviting people to use it, is absent.

Urban space is not two-dimensional. It is not simply a ground plan. Additional geometrical elements are needed to complete the sense of a three-dimensional enveloping boundary. Those elements work in the vertical dimension, and arise from the scales of architecture, not urbanism. Much depends on whether the details of the surrounding walls transmit messages that are either psychologically friendly or hostile to those who visit the open space. Mirrored or transparent curtain-wall façades diminish the visual sense of enclosure of a public space, making it less informative, less interesting, less friendly, less functional. On the other hand permeable solid façades showing organized complexity (as defined by their aligned symmetric doors, windows, and other details) improve the functionality of an urban space.

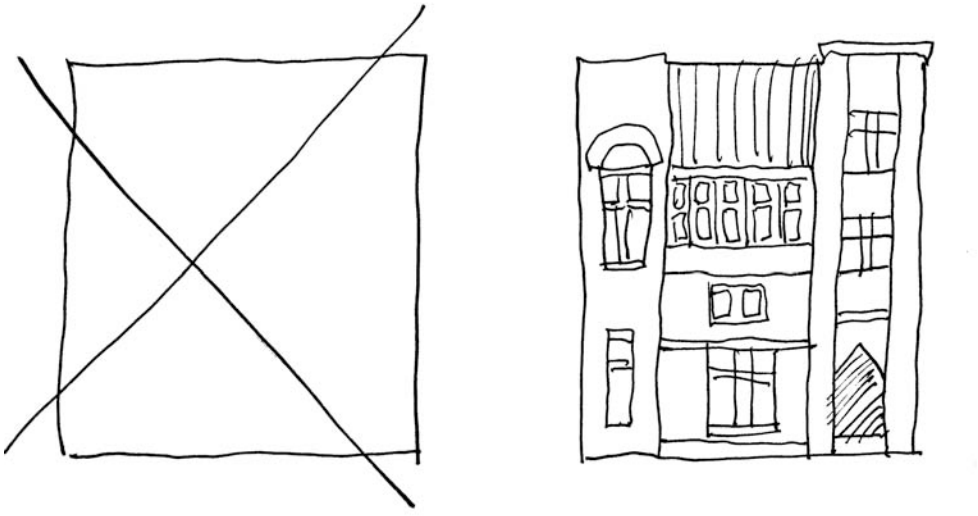

Figure 5.2. The humanity – and consequently the frequency of use – of urban space depend upon the user's experience of organized complexity on the surrounding façades.

Like a framed picture, every useful and satisfying urban space reaches visual completion at a certain height off the ground. A roof cornice, for example, on facing buildings adds a horizontal lip to the built perimeter of urban space, creating a degree of concavity that enhances the feeling of enclosure (Salingaros, 2005: Chapter 2). Yet such framing edges are dismissed as inessential because their original function is not understood; yet they play a major supportive role in the definition of reassuring urban space through the principle of concavity.

In Volume 3 of *The Nature of Order* (2005) Christopher Alexander introduces the concept of "hulls" (as in the concave hull of a boat) in public space. This reinforces the idea of coherent public space that promotes the sensation of being in a giant outdoor room, a room without a ceiling. Alexander also describes the process of designing indoor rooms whose volume and boundaries offer the qualities necessary to induce psychological wellbeing. Altogether, we possess a set of powerful tools for creating coherent living space, interior or exterior, defined by the characteristics of its enveloping and sheltering boundary.

Living patterns enhance our lives and health

Humans have used patterns for millennia, extending biology to shape the built environment. But living patterns as studied relationships among design elements may seem irrelevant when interpreted, as they often are, in the framework of a purely formal, sculptural architecture.

Living patterns have immediate consequences for human health and life. They are not simply a matter of individual preference. The relationships embodied in living patterns help create an environment with healing properties. Faster healing after surgery, for instance, depends on exposure to natural environments, and buildings that have the right mathematical qualities mimic this effect. The backstory became evident with research on the concept of biophilia and evidence-based design that arose from it (Browning *et al.*, 2014; Kellert *et al.*, 2008; Mehaffy & Salingaros, 2015: Chapters 11 & 12; Ryan *et al.*, 2014; Salingaros, 2015). Patterns not directly linked to biology may still be interactive or social, acting together on different scales in a way that mimics nature.

To read the design framework of 253 socio-geometric patterns (Alexander *et al.*, 1977) is to immediately feel the patterns, especially the biophilic ones, to be true in a visceral sense. Living patterns make design a more participatory, vernacular, even democratic process, working to push back against the myth of the "genius" (and often authoritarian) architect.

Some patterns rely on experiential psychology, driving humans to feel comfortable instead of uncomfortable in different types of settings. Others relate to our visual and spoken communication with passersby, be these sight lines, proximity, and other factors that promote or discourage interaction. Human contact is required for the wellbeing of adults, and especially, at either end of lifespan, for both the emotional formation of children and emotional health of the elderly.

The pattern format recommends a set of design constraints; relationships that narrow the specific expression of any given design solution. This constraining specificity enables the transmission of such healing knowledge from one culture, historical time and place to another (Salingaros, 2005: Chapter 8).

Patterns are an adaptive design tool — already available, developed previously by someone else. Their documentation saves architects an enormous amount of work. They need not rethink everything to implement a new project. The flexibility of living patterns means that what is re-used is only the most relevant structural relationship, conveyed as an evidence-based proposition. A living pattern does not merely copy an image from the past but implements the latest upgrade. In this sense, living patterns are tools of evolutionary, adaptive design (Leitner, 2015; Mehaffy & Salingaros, 2015: Chapter 18).

6. Why Do Some People Choose Oppressive Environments?

Our emotions validate adaptive design

The act of building, a man-made transformation of the natural environment, is an imposition on nature, necessary for human habitation. The process of assembling architectural and urban form, along with its underlying geometry, can differ radically: either it is inspired by and sympathetic to natural processes, or it is deliberately opposed to them. The difference between natural and artificial is fundamental. Architecture and planning that use unnatural geometric methodologies will inevitably conflict with nature. Often, forms that rely upon visual innovation as their sole inspiration reap acclaim for their architects. Unfortunately, structures that conflict with the processes of nature are ultimately unsustainable.

Traditional design approaches are utilitarian. Their processes and forms arose over generations by selection among natural alternatives, hence they are more sustainable. The most effective designs use evolved energy-saving solutions for building — factoring in local climate, local materials, and knowledge of local customs. Taking this more scientific approach, we can solve, dependably, problems of sustainability and human health.

Some environments soothe and heal; others induce anxiety and illness.

When people complain that our built environment makes them feel uncomfortable, they are dismissed as "old-fashioned" or "unappreciative of contemporary design". But ordinary people's reactions are in fact correct. Only architects and other design professionals, after years of conditioning in architecture school and practice, are able to override deeper biological instincts telling them that a structure is hostile (Salingaros, 2014). Architects have long used formal criteria to design and build structures that do not accommodate human sensibilities. They treat criticism by the public as proof that their designs succeed in provocation, which they equate with originality.

The root cause of profound disagreement on architecture between trained architects and the public boils down to whether or not a design embodies living structure (Mehaffy & Salingaros, 2011). Reconciliation on this point is impossible. Living structure is the antithesis of provocative. Like it or not, the search for innovation through provocation renounces life-enhancing environments. And those architects who insist that better education will teach the public to love the same buildings they love do not understand human nature.

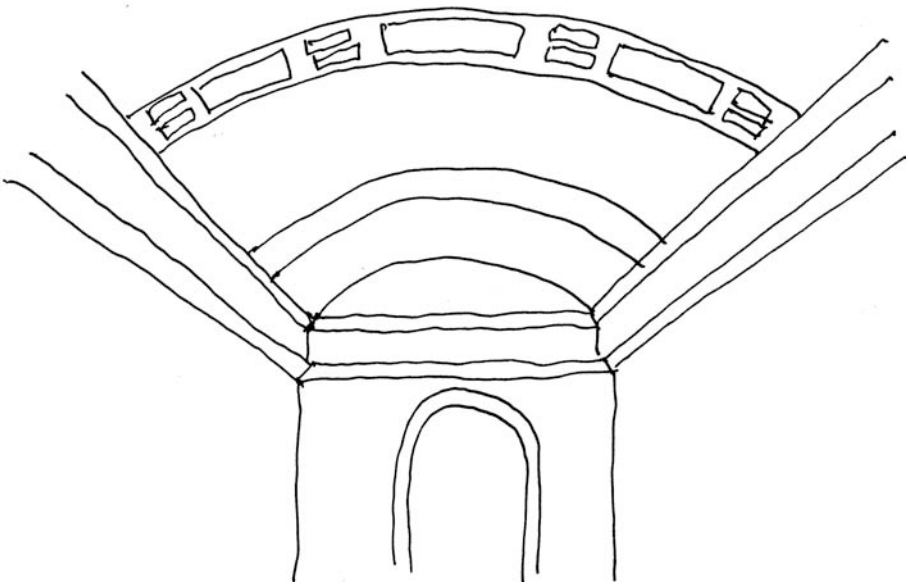

Figure 6.1. A tall concave ceiling enhances activities taking place in this grand room, but few people consciously attribute the positive ambience to the geometry.

We could change our design criteria and adopt a set of mechanisms and relationships, such as design patterns, shared by all "living" creations (Alexander *et al.*, 1977). If the design of a city, a neighborhood, a plaza, a building, a room, or a window shares these living qualities, then we can be fairly sure the built structure will work well for its users. That would solve the problem.

Table 3. Criteria for adaptive design success:

1. The basis for judgment is both practical and psychological.

2. Created forms and spaces are adapted to the human function they aim to accommodate.

3. The forms and spaces make people feel secure rather than stressed.

4. This complex network of sensations acts subconsciously.

5. Body signals tell the truth, especially when they contradict the user's expressed opinion.

A positive emotional reaction is not usually noticed because it is largely instinctive. It aligns with human neurobiological response, which leads to a healthy state. On the other hand, a negative reaction to an unnatural form and space triggers shock and anxiety. Our body is warning us of danger in the environment.

Yet in most contemporary architecture, innovation is based strictly on visual appeal. By rejecting practices based on science and utility, architects have opened a deep and perilous gulf between innovation that celebrates an abstract image and innovation that provides a healing environment. To force the public to put up with dysfunctional, unhealthy design solutions is not an accomplishment that architects should be proud of. Therefore, design professionals must break out of their conventional thinking and embrace living patterns in their work if they want to help reconstitute what every human deserves: a healing environment (Salingaros, 2015).

Design rules that arise from the study of biological form, and also from traditional and vernacular architectures, produce a human-scaled environment. Most of the world continues to build its modest houses and complex urban fabric according to adaptive, intuitive rules. The vitality of traditional cities the world over is due to unwritten patterns. Self-building, or vernacular building, which lies outside the officially-sanctioned architectural paradigm, nevertheless has the possibility of variation to adapt it to human needs. The problem is how to get the profession to accept what the rest of humanity is doing, and identify the essential qualities of a healthy built environment.

Ceiling height and emotional wellbeing in rooms

So far we have not sufficiently reflected on architects' responsibility for how they influence the emotional lives and long-term health of their fellow human beings. In fact the 20th century industrial paradigm does not take into account the inevitable reactions of the natural system in general, and the human actors in particular. Denying human nature (and the very mechanism of life) becomes an essential precondition for shielding inhuman environments against legitimate criticism. The architectural media ignore scientific results that point to adaptive design errors in buildings that architects have been in the habit of erecting during several decades.

How can a more subtle attention to the malleability of built form create living space? Psychology suggests strong constraints on the shape of ceilings as they define the experience of indoor space. We tend to feel more at ease under a domed ceiling rather than a flat ceiling. Depending on the dimensions, a dome or vault gives a comfortable sense of being enveloped in the space. Variations of ceiling geometry and curvature cause major changes in user wellbeing (Alexander et al., 1977: Patterns 190 & 191, see Section 3, *Living Structures Should Come From Living Patterns*). Flat, horizontal ceilings have a generally neutral effect on users. Symmetric pitched ceilings are also acceptable: they approximate the perceived enveloping effect of a cylindrical vault.

Departures from vaulted, symmetric, and flat horizontal ceilings generate a feeling of unease. Flat slanted mono-pitched ceilings sloping only to one side could make us feel anxious — their lack of bilateral symmetry pulls us horizontally. Then, anxiety definitely increases under a ceiling that drops downward in the middle. A

sagging ceiling perceived as "coming down" on our head produces considerable alarm. This ominous effect is felt with a ceiling whose center hangs, such as a catenary sheet that is experienced from below as convex, or a symmetric negative pitched ceiling angled downwardly.

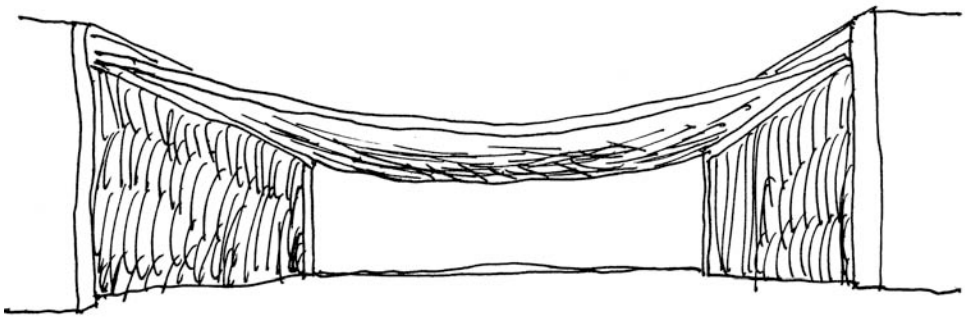

Figure 6.2. Although it looks perfectly fine in a model or rendering, a heavy convex ceiling creates an ominous sensation so that people experiencing this space don't enjoy it.

For the standard flat horizontal ceiling, the floor-to-ceiling height is very important for shaping our psychological response. Traditional ceiling heights originally followed sensible, commonly agreed upon standards. For example, in the East people sit on the floor, so domestic ceilings tend to be lower. Rooms in owner-built dwellings in Europe were sized to satisfy the psychological comfort of their occupants, and ranged from 2.6 m to 3.3 m (8 feet, 6 inches to 10 feet, 10 inches). These dimensions were established as minimum standards in many European municipal building codes. For those who could afford them, even more generous residential ceilings prevailed before World War II, with many measuring 3.50 m to 3.66 m (11 feet, 6 inches to 12 feet) or more.

Ideally, rooms should have ceiling heights that vary according to function and intended degree of public use or private intimacy. Several discourses are devoted to this crucial topic (Alexander *et al.*, 1977; Salingaros, 2005), broadly defined. Practical results for design come from a more general investigation of how living patterns help to define a psychologically secure space.

Le Corbusier's monomaniacal insistence on ceilings that he could touch, which he justified with a mystical numerical system that has since been debunked as nonsensical (Salingaros, 2012), set a floor-to-ceiling height of 2.26 m (7 feet, 5

inches) that violated French building standards, which were waived for him by the housing minister himself. We are still stuck with those low ceilings today!

Construction in the 20th and early 21st centuries, fueled by opportunism and extreme cost cutting, squashed people under oppressive ceiling heights of 2.13 m to 2.44 m (7 to 8 feet), turning dimensions below historically minimum limits into present-day *standards*. This violation was reinforced by an industrial design aesthetic. User reaction based on human feelings was no longer recognized by the industry after commercial motives were accepted as a priority.