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Guiding Patterns of Naturally Occurring Design:

Elements

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Abstract:

Pattern-language can be used to describe transformative ways of resolving disparate forces in complex contexts, making explicit the ancient practices of holistic architectural design, creating new forms with living quality. Discussed here are ways to use pattern-language for learning from recurrent design patterns of nature. Common patterns of naturally occurring organization and transformation are used to search in great repositories of natural design patterns and find diverse living examples from which to learn. For example, the familiar way designers work from early concepts to finished products is can be described as a recurrence of the natural process of complex designs developing from small beginnings to emerge in new forms. The technique of "pattern search" uses a "dual worldview" to separate the subjects of conceptual models and observed natural forms, allowing attention to turn back and forth from one to the other as one studies their connections.

Keywords:

Natural systems, design patterns, pattern language, pattern search, pattern repositories, growth, transformation, living quality, dual worldview, object-oriented science, structural etymology

1 Introduction

The organization of this report, the choice of topics and their order, came from needing to introduce a broad field of research. Over many years of systems science research on the complex patterns of natural systems and their naturally occurring designs preceded this effort to present it for thoughtful observers and designers. So the original work needed to be translated into a pattern-language vernacular for communicating with a wider audience. It originated with studies of complex and eventful patterns of transforming natural systems, convection, growth of various kinds; in rates of evolution and culture change (1979, 1995-07). The paper is arranged somewhat like a series of vignettes, introducing numerous related topics, alternating general discussion with deep dives into advanced topics.

That is a somewhat pedagogical choice too, of presenting core subjects as a way to introduce a broad complex subject. The alternative would be to condense a general survey of the field, sure to be incomplete and likely less informative. The approach is both hoped to follow a logical sequence and to cover subjects both sufficiently developed and of particular interest. So the effort is to provide a good sampling of the field that giving readers places to start their original thinking. So each topic presents various parts of interesting problems, and some of the kinds of solutions explored, hoping to give both advanced and beginning readers interesting and useful points of entry.

1.1 Origins

Christopher Alexander's motivation for developing pattern-language seems to first appear in his books "Notes on the synthesis of form" (1964) and "A city is not a tree" (1965), written when teaching architectural theory at Berkley, both about noticing that the organization of nature is not in categories, but connecting opportunities. He also recognizes a missing richness in the patterns of modern design, "some essential ingredient missing from artificial cites," compared with treasured traditional cities if the past. He linked it with a loss of rich

interconnections, that made modern urban design relatively dull and lifeless both aesthetically and unwelcoming as places to live. What was missing seemed to Alexander to be a pattern of overlapping complexly in natural opportunities for connection. He called it "a semi-lattice" form of relationships that would offer a richness of unplanned or opportune connections, as we see as centers of life all over nature.

My interests in the late 1960s and 70s also included the cheapening of life in the wake of 'progress' and the lifelessness of commercial design but in the context of the social changes of the late 60s and early 70s. That was a decade after Alexander's first inspiration for pattern language, his discovery of orderly organic design of an Indian village (1963). A decade later I was just graduating in architectural and environmental design at the Univ of Pa. in Philadelphia[1] and hearing drumbeats of objection to "the system" that seemed to be controlling our lives.

His starting point was discovering how the universal connectedness of living things so differed from mathematical theory. Mine was discovering the needs of individuals differed from what I studied in physics.[2] That confronted me with much the same basic dilemma Alexander faced, though, a world in which economic development driven by escalating financial demands increasingly dominated. It made cities and buildings increasingly "lifeless" and meant that good design would be largely for the very rich. We both had architecture and its focus on context and ancient practices as a preferred foundation for studying the systems of life. So I focused on a world of transformative natural processes and he on the holistic designs for living. Those are both subjects that physics treats only as "undefined."

What I eventually found was that the great success of physics as a language for nature was also very selective. By focusing only on relationships that can be defined mathematically, it excluded questions about things that are defined organizationally, the individuality and liveliness of nature. That departure led me to study the wonderful things that are possible in-between the laws of physics, understanding physics as describing boundaries within which unique kinds of

[1] GSFA MFA in Archt. & Environmental Design, 1974
[2] St. Lawrence Univ, Physics, 1968. See also JLH CV (2015)

organization and individuality can develop. That and architecture leads to interest in whole systems that provide fully satisfying services, connecting nature and humanity in their full contexts.

One can control various things, but the usual way to succeed is to be selective, and create a good secure home and with connecting access to services that arise from external connections. Those would sometimes be to go “fishing in the big pool” and sometimes on a short circuit of familiar spots. That way, ideals of security and seeing what develops work together, organically. It is a holistic task, for serving multiple interests, working with and around the various predictable limits. Looking then, to understand the sources liveliness, I eventually recognized that what physics defines are not “determinant causes,” but “limits of opportunity,” a big difference. It is the upper and lower bounds of those limits within which the liveliness of accumulative development emerges. That is also the part of our information about nature that traditional science leaves unstudied, one of the open spaces in which design and natural systems work within.

This kind of insight, about where to look for the liveliness of natural designs became clear only as a result of my microclimate studies of the constantly evolving systems by which energy naturally moves in buildings. In studying interactions of radiation and convection produce complex ways for heat to travel I found I could also closely study various lively emerging designs. That let me devise a sort of pattern language for documenting them. It was a discovery experience both quite different and similar to Alexander’s, responding to similar complaints of the time, but coming to many quite potentially useful but different findings (Henshaw 1979, 1995-04).

My first real hints to how natural organization enables energy flows were during school, noticing the great energetic waves of work that reverberated in the design studio. Great crescendos of effort expanding on some simple beginning is a highly recurrent pattern in life and nature. During work in the studio, one occasionally pauses and sits up to notice what is happening around you. There were interesting textures of sound in the room reflecting changes in nervous energy and the intensity of work, as the big waves of energy being expended as designs developed. Studio projects always develop from scratch, with everyone working on the same problem, looking for how to start, then adding to the complexity and effort while staying focused on making it whole in the end, or it

fails. Most often, the projects in the studio all go off in different directions, with each individual's effort leading to something distinctly individual.

I also recall being inspired by hearing of Alexander's ideas back then too, well before his first general description of a pattern-language (1977). I recall hearing about how he had found the urban designs of towns had long term spatial memory such as evident in the grand restoration of Piazza San Marco centuries after it had been eliminated. It prompted one of my first deep insights on natural systems. Like a jigsaw puzzle, the removal of pieces of an ecological fabric leaves reverse images of what was removed in the consciousness of the town, to serve as a pattern repository for new and emergent designs (Henshaw 2015d).

What it signified was how if designers were listening to a town as a whole it would suggest new designs that drew on its heritage of wonderful details or themes from the past. A current example is how the Campidoglio courtyard of Rome was the model for New York's 1964 Lincoln Center and has taken some 50 years of adjustments so far to make it one of the wonders of New York. What struck me was not the concept of mining history, but recognizing how that happened all the time when working on any design studio project as well. The pile of drawing revisions that accumulate as one tries various experiments allowed you to go back and scavenge cherished details lost from versions in the past, something discarded and later turned needed to make the work whole. Today designers are less likely to have piles of transparencies to go back through physically, page after page, to let you review the whole evolution of a project to see how it came together, and that is a loss. One can, of course, hope that still goes on in design studios, with prior schemes kept so that missing innovations can later be recaptured.

I also did a thesis length paper on micro-climates and how they characterized local places, and my thesis focused on the design for a sustainable town and its central building. Where that thinking became a study in new science was in the studies, I began a couple of years later, with the field research on how solar energy moves in homes. I purchased portable instruments for recording building climates over 24 hour periods. After setting it up, I would spend the whole day and night taking notes and tracing the developments of both individual air currents and their evolving networks of pathways, by which most natural energy movement in homes travels.

Organization arises as a result of the rather tricky connection of moving parts, since for air to move anywhere other air needs to get out of the way, and so the complex flow pattern has to develop as a whole. The energy accumulating from sunlight is effectively "trapped" by that until the organization to make individual currents and a set of pathway develop. So watching that quickly became a study of the individuality of those designs, and how they evolved as the sunlight changed direction in during the day. The flow patterns would kick up in the morning, reorganize and move several times in a day, and then fade away at night as the energy dissipated (Henshaw 1979a).

After a few months that led to recognizing a fundamental pattern, that all the emerging systems of organization I was watching evolved much the same general way, emerging and subsided by progressive patterns of accumulative development, which on close inspection proved to turn on organizational changes. My first attempt to describe it as a natural pattern was in "An Unhidden Pattern of Events" (Henshaw 1979b). It seemed to imply a very clear opportunity to study the simplest cases of how the local organization of individual systems developed and how it was associated with energy use.

It was also particularly surprising that this line of inquiry appeared not to have been looked at before. I think what happened was that I stumbled upon a fairly practical way to study a wide range of organizational patterns from the dynamics of their energy use, studying nature's equations directly. Other scientists seemed blocked by the impracticality of working with a pattern language when devising equation for emergent organization seemed impractical. Many scientists voiced concern that assuming that nature has organization was going well beyond what science could study, as traditional science lacked, and still seems to lack, a way to measure organization. Without a mathematical way to represent it, the organization of natural systems was thought of as "undefined" and so outside what could be studied.

Years later, what drew me to Alexander's pattern-language was how it changed over time. In the late 70s, I did study "A Pattern Language" (Alexander 1977) but saw no relation to my work at all. I only recognized how our two different pattern languages for nature's designs could work together, his resting more on spatial patterns and architecture, and mine more on dynamic patterns and scientific methods, some 30 years later. A decade after Alexander and his team

defined his methods (1977, 79) his work was reorganized a little and made more versatile as it was adapted for use by the software profession. That made it much more of a universal language of design, one that any profession or field could adapt to their purposes. I was mostly unaware of that side of the spread of pattern language, though, until I was drawn into conversation on its use for describing alternative forms of self-governance in the commons movement, during my work at the UN (Finidori 2014, 2015)(Bollier, Helfrich Eds. 2014)(Roy & Trudel 2011)(Nahrada 2013) (Henshaw 2013, 2014).

What was most useful in how pattern-language had evolved was its basic structure, reduced to its simplest form as 1) identifying all the significant competing "forces" in a given "context," and 2) finding holistic ways of bringing them into balance, usually by 3) discovering a missing structure. Collections of the most versatile "design patterns" would be collected as design principles for recurrent problems. Of course, success is not always possible, but it sometimes wonderfully is. As in any kind of design, one that critically important "seed pattern" is found all the details for describing the solution and means of fitting it to a particular context follows. Making the heart of the ancient principles of holistic design explicit seems to be the great achievement, with emergent qualities synergies and living qualities as the gift.

Like everyone else, I constantly have to work on how to describe these "gems of good design," developing intuitive terms and standards, etc. To develop it into a more widely shared common language, what remains essential is retaining the simple organizing principles common to all approaches. It would be a kind of "layer cake" of principles, resting on a strong universal foundation. So this paper for PURPLSOC and a companion paper for the October meeting of PLoP (Henshaw 2015c) are my initial attempts to apply a pattern-language approach to recording several very interesting naturally occurring patterns of design. A few added mentions of those who inspired my work are in the Acknowledgements.

1.2 Natural design patterns

The "object orientation," of pattern-language rests on the requirement that design patterns need to describe a self-sufficient and "whole" integration of parts with emergent properties of the whole. Upon implementation, they are expected to offer a holistic response to balancing the "forces" found in the "context,"

creating a “center” of organization that acts as a whole. This combination of characteristics is very common in natural environments, such as the myriad types of homes and niches that natural systems make for themselves. One sees them wherever you find individual systems, organisms, cultures, organizations, ecologies, weather systems, economic, and communication systems, and their independently organized internal parts. They all generally have both an individuality of design and a structure of synergistic roles in their contexts.

It is both the ability to see the separations of these individual organizations as wholes, as objects that work independently and also how they can combine to work together as “wholes of parts.” It makes you think of diagrams, but the only adequate ‘diagram’ would be the actual thing, the service, place, community process or event, and the relationships that unify it. So pattern-language is more a language of generalities, than of abstractions, though it might certainly sound abstract at times too.

The focus is also on versatile “recurrent patterns,” that are common enough to seem universal, arising again and again in diverse contexts. For example, a “door” is a “closure for an opening,” a wonderful solution to the need for both privacy and openness. It is something that can be used to bring satisfying resolutions of complex differences in numerous situations. Another example would be “seating things comfortably” as a way to mutually adjust the needs of many things at once, getting them to a comfortable fit. So those elemental patterns become both “design elements” and “end purposes” for learning from as suggestive models. More More complex design patterns, maybe called “house” or “government,” become discussed as guides to what complex design for unifying the forces of common situations. You might perceive a frequent kind of discord to understand, and perhaps call it “friction” or “misfit parts” and try to identify the pattern of forces that is out of balance, like “lack of contact” perhaps. Sometimes you’ll need to formalize the description, get input from others, and perhaps even do random trials. Sometimes patterns are just discussed as observations and passed around informally.

Design patterns are not actually ‘*solutions’ or ‘recipes’ as* much as they are ‘*guides.’* One uses them to guide learning about 1) how to serve a particular context where they might be applied or 2) to help in the study of working examples and their contexts. Here we are more focused on the second, becoming

familiar with the world of natural design patterns we have to learn from, and using them as keys to unlock some of the secrets of natural circumstances where they are found to work.

For example, for the design of a product or service, designers may finish their plans and then direct work for implementing them, but *it is always how nature responds that creates the final design*. After a designer's work is done, it is nature that builds the integration of the design into its real-world context. That applies equally to software or to buildings that designers produce, or public policies or laws passed. How the living systems to respond to the designs applied is what finishes the design and defines how it works. Of course, as with a home having whole new lives with each occupant, the response of the context to a design can vary with changing use.

What will also matter is how well such designs happen to work for *both* the communities that are serving the design and those being served by it, both the served and serving communities. Purposeful designs are general means of ecologically delivering services from one community to another. How those and connected communities "heal in" around any change in design is nature's living response.

As with a new product, restaurant, law, or idea, it is the environmental response that determines if and how it thrives. Lifeless places are ones the living environment does not respond to and does not take into its living designs. So in functional terms, what design patterns may describe as "solutions" are not the solutions. The real solutions are the matching of the living relationships of those serving and being served. Some designs make that easier, some harder. So what design patterns do is describe promising frameworks for getting things to work out holistically, to allow some part of nature to grow into and welcome, or at times not.

From the software community, Jan Borcher (2001) nicely states, "a pattern is a proven solution to a recurring design problem," one that:

> "pays special attention to the context in which it is applicable, to the competing forces, it needs to balance and to the positive and negative consequences of its application." (Borcher 2001)

Jennifer Tidwell (1999) touches on the heart of why framing them as simplifying ideals of design makes that possible:

> "They are not abstract principles that require you to rediscover how to apply them successfully, nor are they overly specific to one particular situation or culture. Instead, they are somewhere in-between: a pattern describes possible good solutions to a common design problem within a certain context, by *describing the invariant qualities of all those solutions*." [italics added] Tidwell (1999)

That Alexander's pattern-language relies on defining "whole working units" of design seems to have provided the model for the software design innovation called "object-oriented design." It offered a way to define and build software on versatile and individually named modules of design, as organizational parts with holistic purposes. So while pattern-language is still used in architecture, that unitized design of linking independently organized parts is what seems possible to spread to diverse other fields, like education, community building, firefighting or even medicine, all finding a better way to understand the needs of their work. The possibility that it might also lead to "object-oriented science" is discussed briefly at the end, in section 4.2. The focus here is not on applications, though, but on applying pattern-language concepts to learning from naturally occurring patterns of design, and nature's extensive use of independently organized parts.

The companion paper (Henshaw 2015c) focuses on a particular application, a design pattern for guiding software engineers on "mining living quality" to raise the value of their software designs. The simple idea is to follow the workings of the intentional parts of a design to discover better ways to serve the committees of both the providers and recipients of the service provided. It is a variation on "getting to know one's providers and customers" that pushes the limits, usually a very productive thing to do. Knowing one's providers and users helps you know what they really need, understand how a product or service fits into their lives, and so become able to offer a truly full service.

The focus in this paper is more on how to recognize the "object-oriented designs" of nature, learning how to think about and work with them, identifying their design-patterns, and just watching them as they develop. Generally speaking, nature's individual designs have distinct origins and multiple stages of growth and development, as living systems have, with stepwise growth that progressively build-up and then builds down again, to reach a climax with maturation. That is the universal story arc of life, of rising and falling action with real results,

proceeding from small beginnings by a chain of events filling in all the details to reach a climax in a completed final design.

The big difference between stories and natural systems, of course, that one has a narrator, and the other is a "life" that tells its own story as it develops and eventually declines, intensely internalized and seen differently by every observer. These are some of the mental postures one needs to use to separate one's thinking about a life story and the life cycle of naturally occurring designs themselves. More are discussed in the next section, on the "dual worldview."

Section 2 introduces what seems to be the two most universal of natural design patterns, 1) the common life cycle of natural designs and 2) the homes for them built in the process, that are one of the footprints and artifacts they often leave behind. Almost anywhere you see a process of development underway you find it providing for the home for the energy using organization the design enables. For example, that is the way the growth of our bodies provides the home our internal life to eventually be left behind, as does the growth of a business providing its home for its operations and culture, to be cast aside sometime too.

Section 3 offers a "starter kit" for working with natural design patterns composed of a dozen-plus-one key strategies, arranged in four groups: 1) steps to natural pattern study, 2) discovering patterns of transformation, 3) the use of pattern templates for writing or recording "design patterns" to preserve one's efforts in a way others can understand. The last group is 4) describing four great natural and cultural pattern repositories one can learn to search, to open up the world of natural patterns to any observer.

Throughout I'll mention uses for the very helpful natural pattern discovery technique called "pattern-search," the use of one pattern image to scan a context for others similar or related. That helps expose the search pattern's many variations and different roles in nature. For example you might have a set of food ingredients and think through all the things one can do with, and identify what missing ingredients are needed. One might also look for all the ways to respond to plausible crises or as a designer search all the examples of doors to understanding what they afford in the wider context.

Why it works is that nature creates many endpoints for a given starting point, and so creates both unique designs and diverse variations on them in multiple contexts. So frequent recurrences and varied applications of classic designs are

endemic and present a valued resource for learning. If one is working on a design that needs a "vehicle" of some kind you might sort through all the kinds you can think of. For example "vehicle" can be generalized as allowing "movement," and seen as "a conveyance" as for riding on something, or it might be a "channel" for moving along something. It might also be a "medium" for moving *in* something, or for moving a reaction like a "catalyst" that propagates the chemistry of something. Each of those major types of "vehicle" could hold secrets about how nature uses them.

1.3 The dual worldview

There is a very basic reason to learn how to separate our two natural worldviews, our directly sensed and observed impressions and our mentally composed interpretations of their meaning. Those two views work together so seamlessly we can miss how very different they are, one attached to nature the other a detached construct of what we think. We need them both, first paying attention to naturally occurring sensations, observations to be interpreted through our cultural and personal filters to compose what they mean to us, perhaps verified by turning our attention back to the raw observations again. That creates our 'normal' internal view of a world; we define for ourselves. The reason to look closely at that separation is that otherwise the "composer's view" often takes over and the "observer's view" tends to get lost. If we lose touch with the observer's view, we are likely to become prisoners of our cultural silos, unable to check the facts of our own experience, puzzled by why the whole world seems captivated by irrational beliefs.

I've certainly struggled with it myself, and writing about it has been hard. The two views are two sides of the same coin, one's own composed view and meaning of things, the usually hidden other side, their root connections to nature and experience. So unless you look at both sides, shifting views, the other side seems to disappear. What I do to help me break free and keep the two views in balance is to pay close attention to key differences between my observer's and composer's views. One is an internal view, for example, and the other external.

Closer observation generally 1) reveals richer and unexpected varieties of features, textures, and smells, for example. Because natural systems are following their own internal designs, closer observation generally 2) exposes independently

lively parts. That second check for original observation is the one that first caught my attention, noticing that no matter how controlled things are natural systems will always somewhat "misbehave" because of their uncontrolled parts.

The meaning expressed by the composer view of the observation is more of a deduced opinion, with all parts harmonized around an emotional theme, so kind of 'flat. If rechecked, it may also just return the same answer, like a scientist checking their theory to see if their data is correct. The composer's view also produces relatively "flat" images, flattening the world like the lens and imaging sensor or film of a camera does. The flat images in the mind or camera are easy to store but are utterly inadequate to explain the richness and diversity of the real thing, which Ross Ashby's information theory (1956) described as having complexity lacking the "requisite variety" to describe the other.

Learning to separate the observer's and composer's views is primarily to give one good reason to look at both sides of the perceptual coin, and so the two sices can properly work together. Still, explaining it is hard, and doing it is likely harder. Due to individual differences, it is likely best pursued individually, and first by noticing more and more cases of interference or conflict between the two. Then, as best as I can explain, the way forward is to polish one's observer's view somewhat as an artist looks at a landscape, dropping the "veil of perception" and seeing more and more deeply without any interpretation what is there. That way, the beauty borrowed from the subjects themselves is what comes through in the drawing or painting, not just the psychology of the artist. That learning may take real effort, and deep trust too, to sacrifice one's subjective compositions of the world for even a little while to deeply study what is before you with unvarnished attention.

One of the better uses for detaching our composing and observing worldviews comes from discovering the similar two sides to most common words, having meanings that both refer to things of nature and our meanings for them. Take words like 'apple,' 'tree,' and 'person,' or 'door,' 'path,' and 'frustration.' They all refer to *both* the observed thing of nature and our composed meanings of it. Having word meanings contain dual and opposite meanings can, of course, be confusing, another reason to develop an easy way of alternating one's attention back and forth between the two halves of the meaning. You can even split the two halves and use either one with the technique of pattern-search to explore the world

for the possible variety of missing halves. It is a fairly practical way of finding poetic ways of making explicit design statements, as one thing that is nice to be able to do.

1.4 Robert Rosen's model of science

Every kind of work have long relied on a back and forth attention to observation and conception. The earliest of craft trades in the ancient world surely would have used it to accumulate and pass on the techniques of all kinds of trades. The practical foundation of any science is turning one's attention back and forth, between the subject in nature and a predictive method then test with further observations. Fig 1 is Robert Rosen's model (1991) for the relationship between science and nature, showing the dual worldview and modern science, combining observation and theory. It shows the scientific cycle of learning and adaptation, collecting, and then translating natural patterns into conceptual patterns to then translate back into methods for working on nature. It is a complex and ongoing conversation between the testable patterns of nature and our ability to develop ways to use them. However, since our experience is that "the more we learn, the less we know," it appears science may be giving us a relatively 'flat' composition of nature, with inadequate variety to explain the lively world of which we are part.

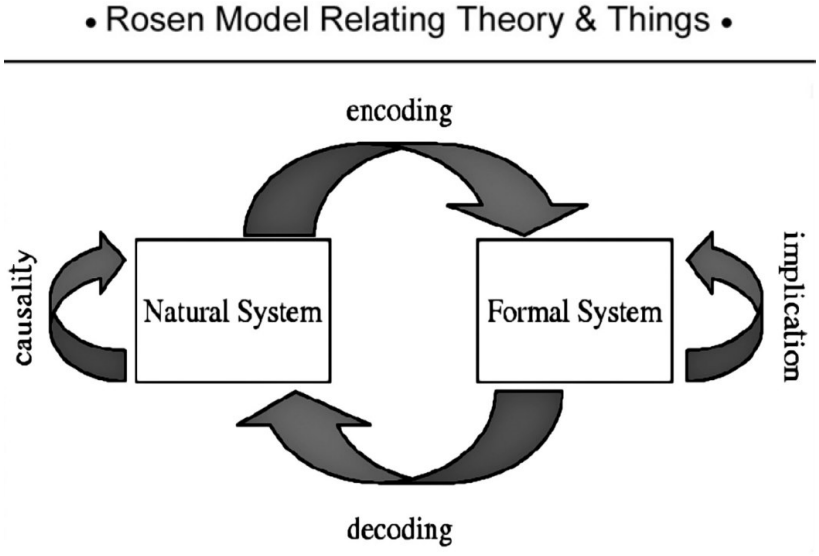

Fig 1. Going back & forth between nature and theory

Robert Rosen's model shows science as a process of alternating attention back and forth between the "Natural System" and "Formal System," first observing natural patterns to "encode" into formal patterns to then "decode" to test on nature, to produce more observations to "encode" as new theory. At the greatest generality, the same model applies to any practice of repeated learning from experience, including the use of pattern-language to discover and communicate high-performance environmental designs. Mathematical science generally uses the model to develop and refine deterministic rules for nature. Rosen, though, developed the model partly for discussing how science may have gotten off on the wrong foot, by studying only deterministic relationships and not the open-ended processes so prevalent in nature (Rosen 1996). For pattern-language, as a kind of design science, open-ended processes for serving natural systems and their lifecycles are a core interest.

Part of the difference between pattern-language and deterministic science is in the kind new questions raised, looking for what services the hand of nature might need, more than to control nature for our use. Pattern-language designs are more for serving the self-organizing parts of a system, like how a lobby provides space for "milling around," presented in a way to convey welcome to the private or business home, not just the calculated space necessary for accessing minimal corridors. Its real purpose is to serve and yield to, rather than control, the life needs of the individuals, communities, cultures, economies, and ecologies it interacts with. So it is intended for purposes other than leveraging ever-growing productivity, for investors the way deterministic science is often used. The question is, of course, always of balance, not extremes.

It is also not necessary to make a general study of how designs serve one's whole environment project, though one could (Henshaw 2018). The purpose of this essay is more to introduce some interesting tools for that, and widen the view of our relation to nature. One will also notice how exploring how to reconnect our meanings with nature puts them on more solid ground and enriches one's understanding.

To solidify one's thinking as you learn about the subject, you can also take any paragraph or new idea, and think of one's self as being in a study group, and play with it from various points of view as a group would. You might even invent exaggerated characters to help generate unexpected angles. I also like

exaggerating the ideals expressed until they become comically distorted. It helps shake up one's assumptions and broaden one's understanding while making the experience more memorable too.

The test of doing it right seems to be whether every time you recheck how the pattern fits the world, you learn something new and unexpected. If you do not get that experience, you may not be looking at the real relationships in play.

2 Two Primary Patterns

2.1 The Natural Lifecycle of Design

I first recognized the natural lifecycle of creative processes in design school, seeing how the 40 people at their desks in the large open plan space all developed their design projects. The work of each one followed a pattern of increasing then decreasing effort to produce the desired end. It varies in shape, but the same crescendo of creativity also is found in every project at home, in business, or other work. First small initial steps provide a foundation for progressively bigger and then smaller accumulating changes, with escalating and then subsiding efforts, as a "storm" of efforts that swells and then fades. Most energy uses may swell and then fade, of course. What makes design different is the accumulative effect of building up something quite new in the end (Fig 2).

Design is a process of fitting together a chain of connecting parts and processes, always a creative search process, but by repetitious stages that you learn to recognize over time. The start is most often a "spark" of insight, an "ah-ha" moment for what might become. That kind of creative flash is needed for large and small projects, as much as for simple little things like going to the movies or making lunch. What follows depends on what can be added by bigger and bigger steps, then by what steps will make the work possible to finish. So big additions naturally become smaller and smaller additions; from framing out to filling-in and then finishing details as the work approaches completion. That cycle is generally also driven by the risk of running out of time or money or materials, forcing improvisation to finish. If you think through most any other kind of design, the same applies. The crunch at the end appears to come from the initial

intent to “think big,” and being unable to envision the big rush of details at the end, letting one overdesign the beginnings.

Fig 2 shows the seven basic architectural design phases of getting a building design started and finished, with the area of each labeled prism roughly corresponding to the length and intensity of the effort. The same phases would have their corollaries for any other kind of intentional design, like “developing a new product” or even “making dinner.” If the work “starts on the right foot,” everything can go much more smoothly, and allow the final “bringing things to resolution” to be easy. How any design will proceed is not easy to tell at first, as “every design is a journey,” with each stage a rethinking of the whole. They might either proceed by well-practiced stages or take wholly unfamiliar turns; it is hard to know ahead. Every change can unexpectedly change the whole, like making a painting or writing a story, caused by a combination of projecting from small to big patterns and the improvisation to take advantage of accidents in bringing them to completion.

• Stages of Design and Degrees of Effort •

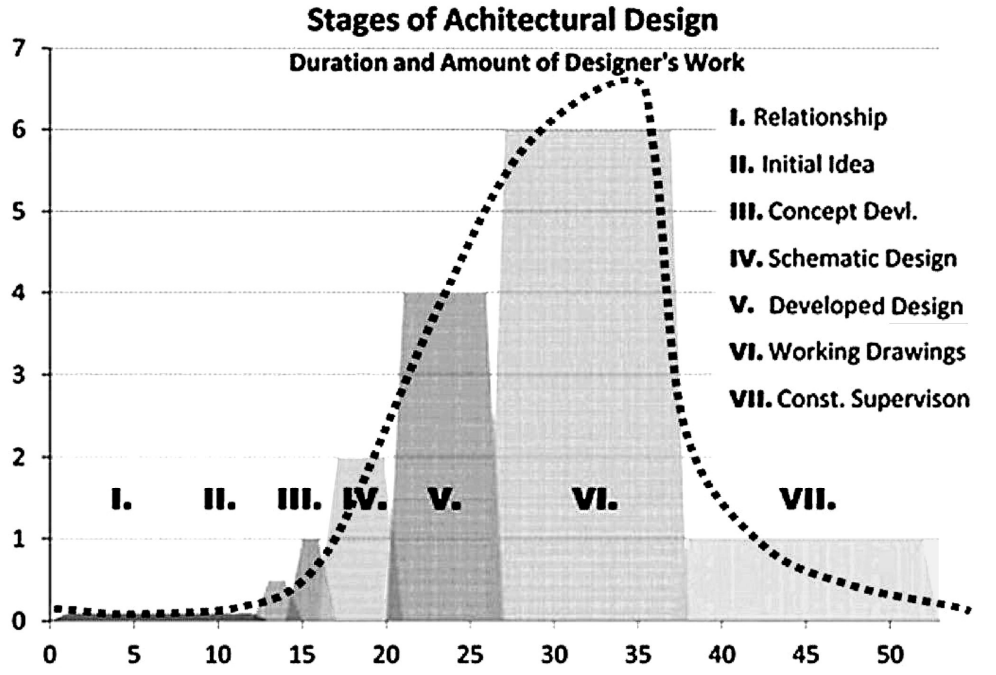

Fig 2. The general development pattern of professional design

Fig 2 & 3 show the design as being finished before development, as is usual for buildings. The designer will often be involved in watching over the construction, providing some finishing touches and clarifications, but their work tapers off until the final 'punch-list' of defects is prepared. Then at the very end, the door key is turned over to the client, marking the time when the house becomes a home. Here in Fig 3; the design period is represented by its wave of effort and the development by accumulative steps of building.

Naturally occurring designs, like any of the complex growth systems of life and nature, follow much the same general stages of design, starting from small "germ" to then build up a flurry of additions before stabilizing. The big difference, of course, is that for nature's designs, the design and development periods are the same. There is 1) no designer and 2) nature's complex designs "fall together" during their process of growth (Fig 4). That is not only the case for basic energy systems like storms but also for cultural systems, ecologies, industries, even social networks, and careers. Their often complex designs emerge as they develop. It is also the case for plants and animals beginning with a fertile cell, and the resulting design only emerging with its stages of growth, much of which is history and context dependent. How growth faithfully reproduces the type of organism, but always with unique individuals, suggests natural design is both design and development, more like a "search" than following a "rule."

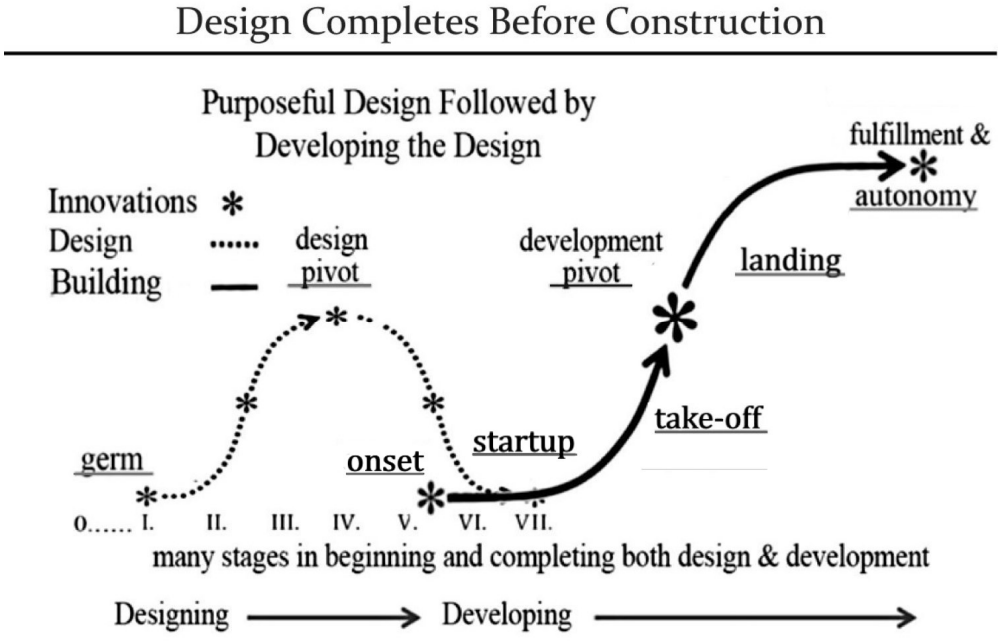

Fig 3. Intentional design preceeds the development process

Another sign that "natural growth" is a design process, rather than a rule, is how growth has the same pivot in the middle from start-up to finish-up stages of design completion, at an apparent peak of perfection. Just as for intentional design, natural growth begins with some creative "germ" as a starting pattern to build on. In the growth of organisms that initial "start-up" phase leads to multiple stages of development and maturation, each needed as the foundation for the next, also like the growth stages of completely improvised systems like cultures and social networks. This curious set of similarities and many more one can find, is one of the key guiding patterns of naturally occurring design, a "roadmap" for building healthy systems, by a process of improvisational design.

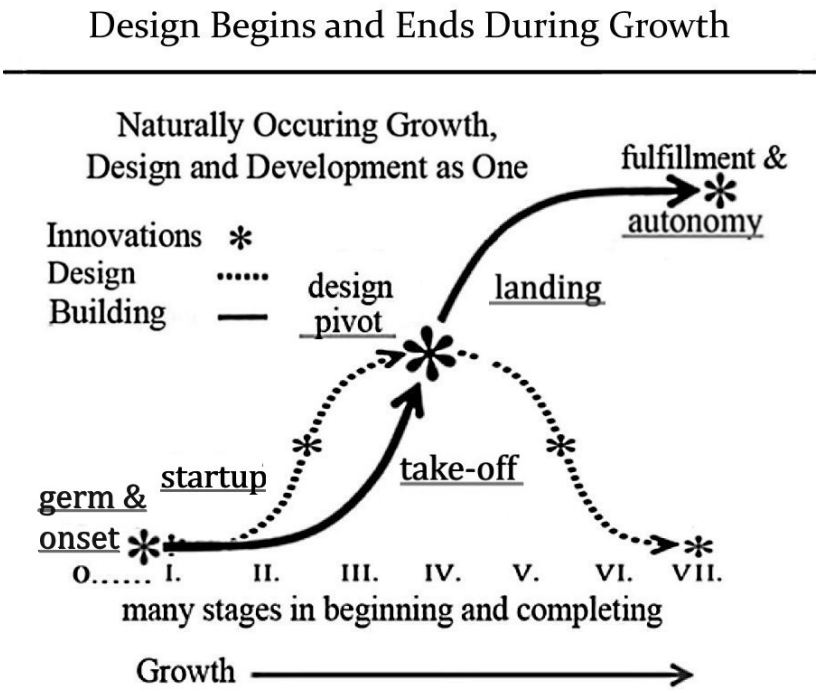

Fig 4. Organic design occurs during development

As businesses and industries grow, their designs develop at the same time, following the natural system model. Even as many parts for their growth are designed in detail before being implemented, those pre-designed parts are still conceived of and added to the business or industry organically. The additions themselves are improvised as responses to evolving market opportunities and business potentials. The pre-design of such added parts is also itself organically

developed, following the natural growth process, starting with the germ of an idea and developed opportunistically. That is also the case for pre-design generally, as for buildings, that the designs emerge opportunistically during their development as for natural growth.

In architectural studio practice, distinct stages of design follow a fairly standard pattern, shown in Fig 2 as I. *The Client Relationship*, II. *Conceptual Design*, III. *Schematic design*, IV. *Developed design*, V. *Contract Documents*, and VII. *Construction Observation*. They correspond to distinct changes in the types of "search" for the next addition that takes place. For example, it is during the "Client Relationship" that starts it that the search for the bold idea of what can be done takes place, and produces the "germ" of an idea from which the whole process develops.

The next three phases, *Conceptual, Schematic,* and *Developed design* are a succession of expanding validations of the initial idea, with a decision whether to go forward made at the end of each, as each stage shows more and mature and confident decision making. Then the largest part of the work is in the *Working Drawings* when the closing of all the financial and contractual arrangements and there's a race to perfect and complete the work within the fixed budget then agreed to. The names might differ for other kinds of design projects, but the same general pattern of stages would be found, even if it is getting ready for a family holiday, steps of increasing scale and complexity to decreasing, as the character and content of the design emerges as a whole.

As any design progresses, the new kinds of tasks branch out again and again. That tends to create an explosion of details needing to be completed, increasing the intensity and complications of the design effort. In architecture as well as in normal office work, the rush to "get it out the door" is a kind of creative panic. Pressing to deliver at the promised time becomes a separate driving motivation concentrating everyone's attention. It need not be a matter of poor planning, but completely natural, that as a design progresses, it creates multiplying demands for finishing things, caused by each new part creating new places to add more.

One can see a similar pattern in biological growth too. The initial seed pattern and the early stages of immature growth, then complete framing of the design and then maturing and refinement of the whole before release for its independent life. Often the least noticed but perhaps most important phase is in the middle, the

Developed Design (IV*)* when the first practical form takes shape. That roughly corresponds to the biological stage called "differentiation," when all of a new organism's different cell types, organs, and skeleton structures appear, very immature but clearly defined. That developed design "sets the plan" and unleashes the real explosion of development to follow.

You see a smaller-scale version of these same stages in preparing lunch, with the five major milestone markers as in Fig 4, the *germ, take-off*, *pivot, landing*, and *autonomy*. Watching those thresholds being crossed also gives you more of an idea of how the natural processes that exhibit unfold too. Variations on those stages are there in the project to send a man to the moon. They are there in the stages of establishing anyone's career. Every step takes a bit of inspired invention, first starting with small tentative steps on which the series of larger and then again smaller steps toward final fulfillment rely.

You see the same pattern in learning, too, moving from immature play to mastery, the formative work to start and the hardest work toward the end. Education starts with early childhood and one's absorption of language and culture at home and then follows a long ladder of ascending levels, each a new growth challenge. What is a useful pattern to recognize is that each year of education starts as a fresh big challenge and is usually completed with a sense of mastery and joy, that cycle to repeat again and again. These stages of growth in learning correspond to real levels of organizational complexity and sophistication of our knowledge too.

An even more general and important pattern of growth and development is the co-evolving, sometimes parallel, progression of organizational development and energy use. Recall the original observation that opened my eyes to how the liveliness of nature arises from the need for organization to allow energy flow, in that case for convection currents. That each is needed for the other provides a key connected way of observing the designs of one's world. For example, noticing increasing energy in a conversation indicates emerging organization in the relationship, good or bad, and seeing a new pattern of neighborhood, or even global, development indicates an emerging economic and societal energy flow.

It is not just satisfying to have that way of observing how the world is working; it also exposes various internal and external limits of what are usually spontaneous developments, a major new advantage for seeing what is ahead. For

example, it generally applies that too intense an energy flow is organizationally disruptive, such as for a new relationship that develops too fast, as a "flash in the pan." The co-evolution of organization and energy use raises numerous other nature/nurture and development coordination questions too. It is also a very direct way in which physical-science and design-science are connected, linking their two differing sets of "laws." Here there is only space to say that noticing the close connection between energy and organization is another key guiding pattern of naturally occurring design. Noting swelling or subsiding energy use does not tell you what design process is taking place, but it does tell you where, and helps you find a general idea of what to look for.

Thinking of design as coupled to swelling and then subsiding energy use also gives progressions of design a series of mathematical markers for following its course. The most important are the five most directly visible (Fig 4 & 5), the *take-off* and *landing* progressions of finite positive and negative feedback, and the *germ*, *pivot*, and autonomy points that start and end them. With a little experience, these signals of systemic change can be fairly easily recognized, something solid to base one's study of how developing systems of any scale are building their transformations.

There are many more useful mathematical markers too, including the various kinds of peaks and saddles in the data curves and their inflection points that normal time-series data curves will show. Such data curves may also have meaningful derivative rates of change displaying the eventful changes in the speed (r'), acceleration (r''), and jerk (r''') of change which indicate the eventfulness of the organizational changes taking place. Time-series will also show changes in the often telling character of the noise in the data, such as its swelling and subsiding. Various mathematical tests can also provide strong evidence of noise symmetry, indicative of variation about some regular continuity (flow) in an underlying process (Henshaw 1999). If there is continuity, there are then also implied accelerations and shifts in accelerations to signal to an observer what may be happening. Those are all quite informative for characterizing the kind of organizational or energy using process identified and how it is changing.

2.2 Elemental forms of Homes

Homes are enclosures that allow good access to the resources of the world around them and within which a home culture can develop a private way of living, relatively free of outside interference. That "simplifying ideal" for balancing the discordant forces of the world is found in extremely wide and varied used. Homes create private worlds, for very stable and individualized working relationships, with regulated connections with the outside. Three simple types are depicted in Fig 5, a *hut*, a *family home,* and a *town hall* to represent a community home.

A biological cell is also a home, for the specialized chemistry within its enclosure, giving the interior design selective access to its outside world of other cells and the environment of its body. The ways a cell, a family home, and a meeting hall serve their interior cultures are quite similar despite their interior cultures being very different. That similarity lets us recognize the universal and common design pattern of homes. Using these and other examples, you can identify several essentials for each type of home you can find, such as both family homes and biological cells having a kind of "center" around which the life of the cell is organized. In the family home or community center, it is the central meeting place, where its culture is shared. In a cell, it appears to be the place where the culture of the cell is stored, its nucleus, where the cell's genetic code is stored and shared. A family or community can call a meeting most anywhere to share its culture and carry on its business, though its usual center will be the main room for regular gatherings, often in a circle, where a family is also surrounded by the symbols of its culture. In my family home, most frequent family centers were around the kitchen and dining tables, alternating with all the other gathering places such as the living room, den, porch, and yard.

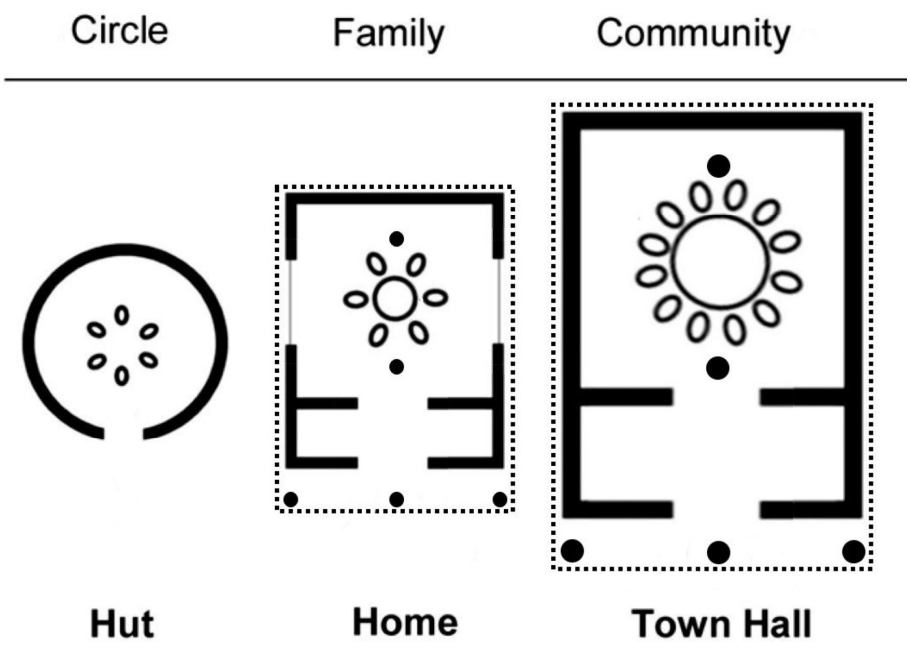

Fig 5. Homes that shelter cultures of equitable living

The private lives of most families are about the same in general and distinctly different in the details in the way personal needs and interests are balanced. Coming together around a table creates a natural *family circle,* with the table not so much connecting family members as equally separating them. The design pattern allows each person to face all the others, have equal access to what is shared across the table, and to be an equal witness all the communication between others so that all that happens to be a shared experience. Much the same relationship exists when sitting around a campfire too, with the fire both bringing people together and importantly holding them apart too.

The Western traditions of home and family seem to have originally come from the early pre-Greek, Bronze Age, design for Aegean family living in homes designed around their hearths. To convey the idea in Fig 5, I show both the model Home and Town Hall designs with the modern detail of central tables and the home with modern windows, both of which the originals would have lacked. The Greek use of the design became the source of our modern traditions of hearth and home as well as the model for formal Greek architecture too (Dinsmoor 1902). The relevance here is the closely linked design-patterns for living and building. It is the columns down the middle to create a spacious central room, an innovation

apparently needed due to the lack of tall trees (ibid), also forces one column to be outside the front entry. The original designs had large low hearths in the middle, with the apparent use for extended family or elder gatherings, sitting around the hearth tending small charcoal fires. If you think about it, that is the only practical use for such a large hearth in the middle of a primitive room. Any larger fire would be suffocating. That the design persisted for over two thousand years and was then formalized in modern greek public and religious architecture attests to the durability and centrality of the principle in early Greek life (ibid, Burkert 1977).

That telltale exterior column seems to be the origin of the exterior rows of columns seen in classical Greek architecture, originally being functional and then decorative. Greek temples and treasury buildings show the clearest similarity to the original design pattern of the ancient Bronze Age hearth-home. It is mentioned here as a quintessential example of interlocking elementary design patterns for living. Having a low hearth at the center of the family home combines very modern design with very ancient, combining cultural and technological design in a way that continues to influence us today. Other than this rare connection of design patterns there may be no direct record of how this unique ancient design for a home was lived in. The only writing from the time was Homer's, and he seems only to mention it as the form of temple which the hearth-home turned into, calling them "megaron."

Even strong family bonds are curiously invisible from a distance. One's own may seem immutable, but another's are centered in the home. If we walk down a street and can see through the windows, we still cannot see the relationships that hold the culture of the home together. So they may not be appreciated until you experience inclusion in (or exclusion from) someone else's family circle, only then exposing how complete a kind of privacy a home life creates. From the outside, family culture is an invisible fortress. From the inside, it is a common universe with quite deep cultural roots, taken for granted, that invisibly passes on its ancient inherited ways of living in and understanding the world. So we tend not to think about these inner worlds we both know so much and so little about, until crossing the boundaries of their personal space and feel uncomfortable and embarrassed by not knowing how to act.

As children, we first find other people's homes deeply mysterious, the homes of neighbors and relatives, full of special things that surprise us and show us how

differently they live. As adults, we are still frequently surprised if we go to someone else's home, and find they have unexpected ways of living. We learn so little about how others live privately; it also can take quite a long time to correct our initial misimpression perhaps until we have had a long close association. So every culture is a "cult" in that way, an "alien" world and way of life with its own deeply rooted ways and manners. To an insider, small cues carry large meanings, which to any outside observer would go quite unnoticed.

As a result, many, if not most of us, find ourselves living somewhat "invisible lives," caused by what makes private lives so private being so universal. It occurs because our lives are designed from the inside. We may also have grown up in one of the many old inherited family cultures, not the subject of the news or stories so much, perhaps filling neighborhoods and workplaces but not in the media, and so mostly unrecognized. That separation is just part of the natural design, that home cultures are so private, a tradeoff for also being places where private cultures can most deepen and thrive. It keeps outsiders from understanding until something exposes what they're missing, letting them develop empathy for the hidden ways of life they may have long been around but remained unaware of.

3 Natural Design-Patterns − Starter Kit

The idea of offering a "starter kit" of techniques for the study natural design-patterns is to offer a collection of approaches to study to explore a bit and perhaps master later. I have not defined either pattern-language or design-patterns, relying on the general ideas to soak in from the illustrations. Design-patterns consist of a particular combination of working parts that have emergent life properties, usually a kind of magical solution. Examples include things like a candle and flame, glass and water, an enclosure with openings, and a meeting table and chairs, all assuming some service to a greater whole. These are what allows nature to "make something from nothing," finding connections that have unprecedented properties that coupled together that make natural organization work lets energy to flow.

Fig 6 suggests a way to think of studying natural patterns as a series of graduations, with everyone at different levels on different things, and the way if climbing the ladder is to look deeper into one's origins, level by level.

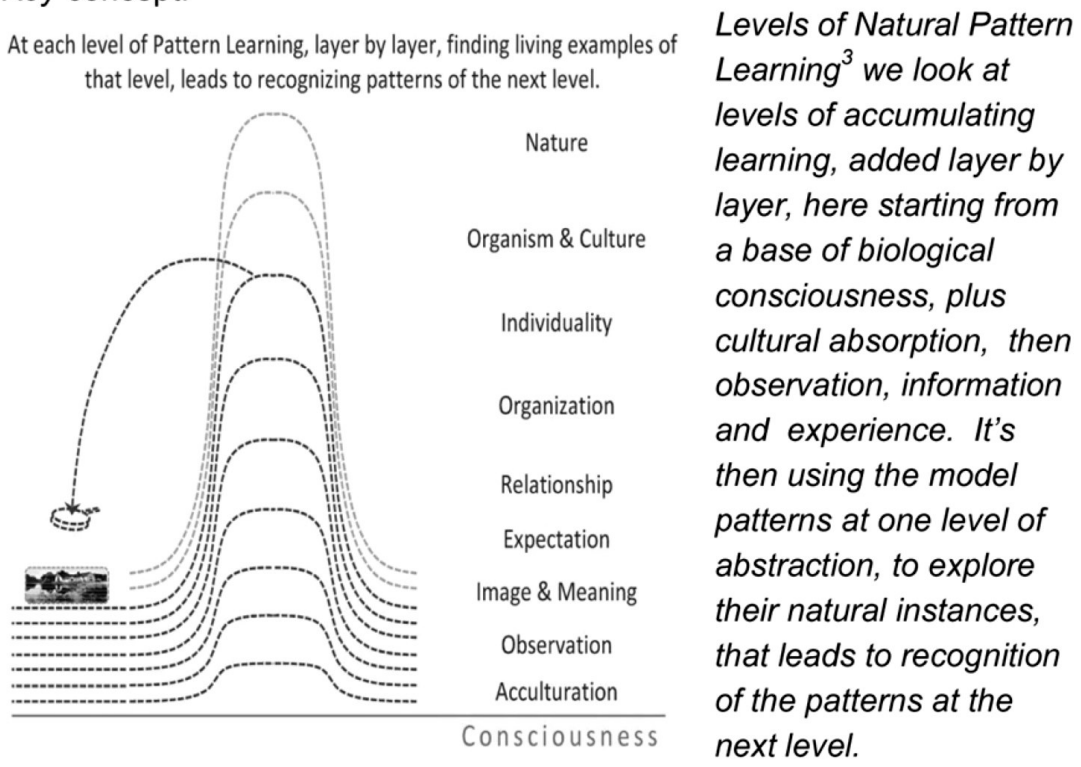

Fig 6. Graduation Levels of natural pattern learning

Each topic in the starter kit is intended to have some easy application, and also introduce a more challenging subject. That uses the "core" approach, combining general discussion with advanced technique, rather than just offering sketchy surveys of each topic. The idea is to give people ideas of what to experiment with on their own. For the ladder of learning in Fig 6, we all start with a great wealth of inherited cultural knowledge and have also added vastly to that with our observations on how life works. So to climb the ladder of learning about the design patterns of life, it would be more a matter of translating what you already know into a more explicit kind of description that can be shared.

. So my main reference for mining natural design patterns combines direct observation and my experience, having borrowed some language and practices from those who went before. Some references that have helped me in working with pattern-language include the collections of the Pattern-language Association

(2015) and the Hillside Group (2015) and the meetings the latter sponsor. It is useful to search for discussions of Christopher Alexander and his formative and more popular writings (1965, 1977, 1979, 1987, 2001-6). There are the books by the urban design critic Jane Jacobs, on the natural patterns of economies and cities and their sources of creativity (1961, 1970). Sophisticated patterns identified by of Doug Schuler (2008) and Sebastian Denf (2012), as well as software pattern design essays by Jan Bochers (2001) and Jennifer Tidwell (1999), were all very helpful to me too.

General introductions and Slide sets by Takashi Iba (2013) and Helmut Leitner (2014) are current and very helpful. Good books on ecology and living systems from a naturalist or "deep ecology" approach are a big help, such as books by or referencing D'arcy Thompson (1961) and Brian Goodwin (1994). Books that tell the stories of history, such as on the history of civilization, language, science, society, and technology are all helpful, as are books on comparative anthropology and subjects like competitive strategy. Books on myths and children's tales often addressing the same issues of "how things work" from a cultural view are all helpful, as well as the Bible and other ancient texts if read as documenting our earliest ways of thinking. Of course, finding great teachers and sometimes carefully listening to things you had not before, are invaluable as well.

3.1 Steps of Natural Pattern Study

The patterns one finds of naturally occurring design become 'guides' when somewhat generalized and used as "model" for "pattern search" for searching the environment for related working examples. Examples found that way are usually varied and rely on features and connecting relationships one would not expect. Those discoveries in the live context are what you learn from, adding to one's mental library of "ways things can work." So generalized design patterns let you search and find varied related patterns in source examples or in one's or someone else's recalled experience. What you find lets you see how the real subjects work, helping you see the kinds of designs that serve both their internal and external worlds of relationships at the same time.

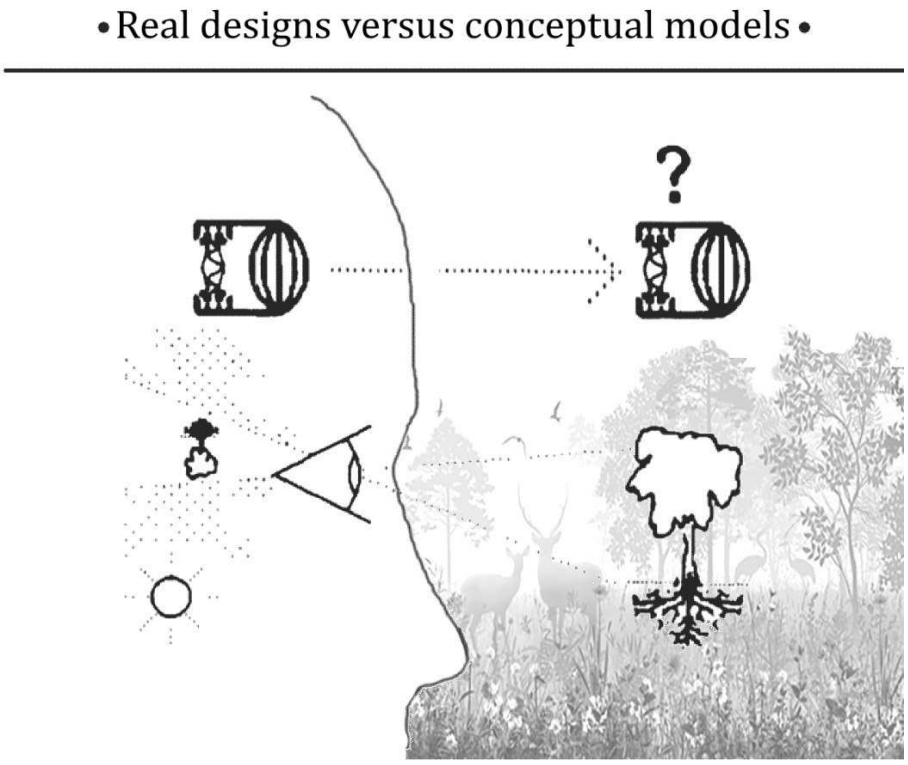

Fig 7. Abstract patterns and their contexts

Say one's pattern idea is 'tree,' and you notice its spreading branches and spreading roots reaching out to connect, you can convert that idea in one's mind to a diagram of a system connecting with itself through its environment (Fig 7). But is that image useful or distracting? Very abstract ideas are indeed useful sometimes, in surprising ways, but it would be a mistake not to realize how distracting they are too. So as part of the exercise of searching for real patterns, one might back away from very abstract images rather than take them to be perfections, as they usually are not. In this case, that abstract model omits the all-important forest floor, fields, and fauna that fill out the highly complex local ecology the tree is part of. The search for the magical organizational principles that make the designs of the world work is not helped by abstract models that distract you from the working context of the designs of interest.

Whenever a theory seems to have become too theoretical, one might then explore the places it is found to see it is practical meaning. The "circular economy" of nature itself is a somewhat overly abstract principle in that sense.

Nature is really not circular in its resource management, for example, though that is what lots of people think it means. Nature's resource management accumulates layer upon layer of byproducts that will never be used again, and streams of energy radiating to space, eventually as much as comes in. As soils build up, they eventually become stone, and decayed vegetation gets buried with the accumulating soils to perhaps become to fossil oils and gas trapped in the rock. Nature also ends up destroying everything she or we invent, generally never to be seen again. What can be said to be least circular in nature is growth, nature's main process for building things. For living things, their growth must end for them to mature and reproduce, and create the circular process of passing on genes.

The circular designs of natural economies all turn out to be quite complex, and always have non-renewable resources and permanent discards. It is not these abstract idea or possible moral principles that make life work, but that nature seems to delight in finding new things to build for having their day. So looking at the context the symbolic circular shape of nature seems to come largely from a fascination with the symbol. The actual circular shape of nature is more like a curve of growth and decay curve with a footprint like a shadow that increases and decreases with the curve too.

3.1.2 Pattern Architecture

Long before Vitruvius described architecture as composed of "firmness, commodity, and delight," people recognized that finding "safe harbors" allowing both commerce and security were also places where the cultures of inhabitants could thrive. It is perhaps the original insight of architecture, also seen in the exceptional durability of the ancient Aegean hearth-home's design. What changed with modern times is partly extraordinary technology, and in part designs ruled by maximizing profit, designs for profitability more than providing wonderful places. What is new in Christopher Alexander's architecture is the use of pattern-language as a way to be explicit about the structures of wonderful places, for reviving some of the secrets of holistic environmental design that architects once inherited. Where it came from was Alexander's combined fascination with

holistic design and mathematics. While studying for a Ph.D. in architecture at Harvard, he took a trip to India, where he developed a fascination with the closely-knit holistic integration of the habitats and cultures of Hindu villages (Alexander 1964).

His sketches of one town plan and its working parts (Fig 8) gave him the spark of initial insight that stayed with him until he made them explicit 24 years later in his seminal writings on "A Pattern Language" and "The Timeless Way of Building" (1977, 1979). In-between, his many experiments in describing these holistic "geometries" led him ever further away from logical organizations of categories or hierarchies of responsibility. What he discovered is better-called the organization of behavioral opportunities, which, in my view, is much like the study of what makes life lively as discovered in about the same period.

The Indian village has a central road that winds around a hillside, from which natural streams of water are collected and stored for the irrigated croplands across the road. The ceremonial and other public spaces bridge the road at one end with the private area with family clusters of mud huts behind. Going into detail what Alexander found was that Each part was multiply connected to all its needs, creating a discrete network of possibility, and that is what pattern language seeks to enable for other kinds of cultures.

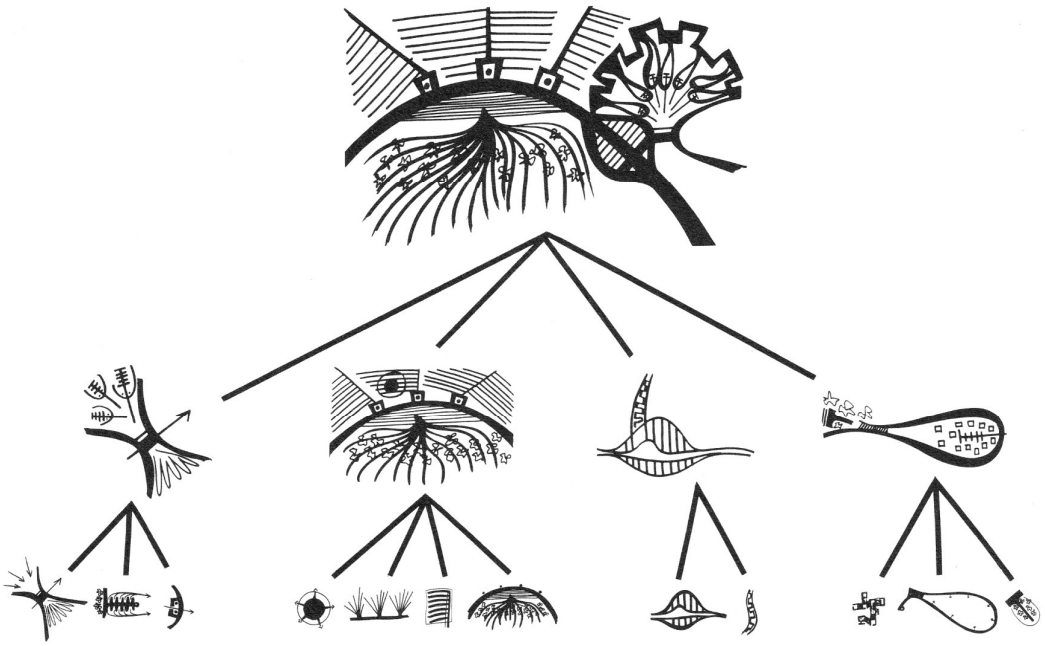

Fig 8. Essential elements of a traditional Indian village design (Alexander 1963)

It begins with identifying the 'forces' of a particular context that need to be resolved, doing so with a design for services that are satisfying in such a complete way as to spread an experience of 'living quality' in their surroundings. Examples would be a receptionist who puts you at ease, a very comfortable chair or stairway, a generous living or dining room, welcome details like a bench in the right place on the street, a welcoming town square, a sunlit forest glade, a smooth rock at the top of a mountain, a form of government with trusted checks and balances. Well-made things, places, and accommodations that exude living quality, natural or fabricated extend the study of holistic designs and their working design patterns that Alexander originated well beyond architecture, creating an art and science of design potentially applicable to any field. The 'patterns' carry an implied intent to be holistically responsive to the needs of varied individuals, their living cultures, and environments, to capture nature's so often exhibited 'motive to serve.'

It is out of that need for fully satisfying service, that tension between responding to forces and the ideals of holistic design arises generally answered only by discovering what seems like a new form of design in every case. That usual need for unique responses is what requires design-patterns to be generic and adjustable enough to fit and be completed with local details responding to the whole of each context. Not only to do design-patterns need to be sufficiently general, but a designer also needs to use them sufficiently free of assumptions. As a visual artist sees without judgment, studying the context of a design without judgment is both important and hard to do, but possible to pick up from studying how nature designs, fitting together responsive patterns of relationships with no assumptions at all, only with what is. One of Lou Kahn's curious ways of expressing things illustrates that ideal of starting designs without any prior design quite nicely. He urged designers to ask "what does *it* want to be," leaving the emerging self "it" unspecified, and to always begin every design by "reading *book zero*," the book of all things without preconception (Henshaw 2015d, Youd 2014). As if stepping off on just the right foot, designs begun without preconception are more likely to satisfy the true situation and seem to fall into place for the living relationships being touched.

3.1.3 Practice

The subjects with clear patterns of design that one can best study would vary with individual exposures and interests. Most influential in an environment tend to be organisms, cultures, and other natural systems going through stages of growth or running into growth limits, both of which also help expose internal patterns of design to work with. To try that think of organizations or family relations as they have grown and change, to compose a growth narrative to correspond to the facts to see where there is missing information and how they are positioned for the issues of the present.

Starting subjects might also include just noticing things "out of place," of any kind, even in history, considered as a window into the environment they out of place with, and perhaps expose hidden histories or potential interventions. The things one is fascinated by are, of course, also good subjects. Fascination lets one study things in detail, and from every point of view, one can find to understand them as a whole. One's home town or city is a great storehouse of complex living systems and cultures that fit together as a result of their separate adaptation, the way family members also fit together as a result of their separate adaptations. It is a structure one can learn from and follow and discover opportunities for engagement. One can often discover unnoticed sub-cultures in any age groups by noticing where groups of people congregate, comprising their homes or "centers" for work, trade, or communication. There one cannote both user relations and the special nature of the time and place that draws them there.

Similarly, one can also explore local cultures by noting their boundaries, even in a schoolyard or on a street, different places will be attractors for different kinds of gathering or separating social niches. You do not usually see it directly, but all those recognizable cultural groupings have central people and places, generally with an enclosing boundary, giving them a cellular kind of design in nature. They are also generally organized around common histories, having their life-cycles with stages of growth that startup and transform or run their course.

Those features make them loose-knit kinds of organisms, usually displaying recognizable stages of emergence, development maturation, and later, decline. The common connection maybe just social style, friendship, related professions, an age group, a neighborhood, a club, or organization, etc. It just takes practice in following one's curiosity about them, taking note of them in a questioning way as

you begin to understand them. Watching relationships develop is both important and one of our best opportunities to watch how natural systems evolve, and will help one understand the transformations of larger and longer-term environmental and social change.

As a general rule, I tend to find what makes for memorable impressions of how things work is a mixture of broad "big picture" impressions and interesting details. With those, one will both recall and be able to return to the same subject, again and again, to raise fresh follow-up questions the next time. It lets me build on what I learned before without forming a specific theory. One could apply that to one's business or business community, just accumulating observations of interesting patterns and details that might come in handy sometime, or do much the same with other groups one is part of.

As one studies the patterns of working relationships, one gets better at recognizing their commonalities and variations. Paying attention to how things work in general builds one's ability to follow how anything works in particular, and begin to notice patterns of design that are particularly satisfying. For example, a particularly satisfying design seems to be at the heart of any good relationship. It is, of course, not something a designer directly creates but something much more likely to develop around good design. Designers do not design any of the life that later inhabits and "heals in" around their designs, only the frameworks of services that facilitate the lives of users. It is those offered services that encode the potential for, say, pleasing a client by sharing the beauty and comfort of well-made things, serving a neighborhood and harmonizing its communities. A city, a building, office, or organization gets used by people of many kinds, so almost any design needs to facilitate the lives of multiple communities, making all design a kind of ecological service and caretaking.

Developing an awareness of environments as full of opportunities posed by naturally occurring design becomes a foundation for good design. What anchors and validates the design process is accumulating reliable observations of how things work, seeing unbalanced forces as opportunities. It is what lets you return again and again to similar circumstances, validate and refresh what you found before and discover more the next time, alert to:

1) ways of resolving forces - creating new forms of design
2) treating design as a gift - to both internal and external relationships,

3) noticing tradeoff's - special connections and conditions
4) whole system change – innovation creating new contexts

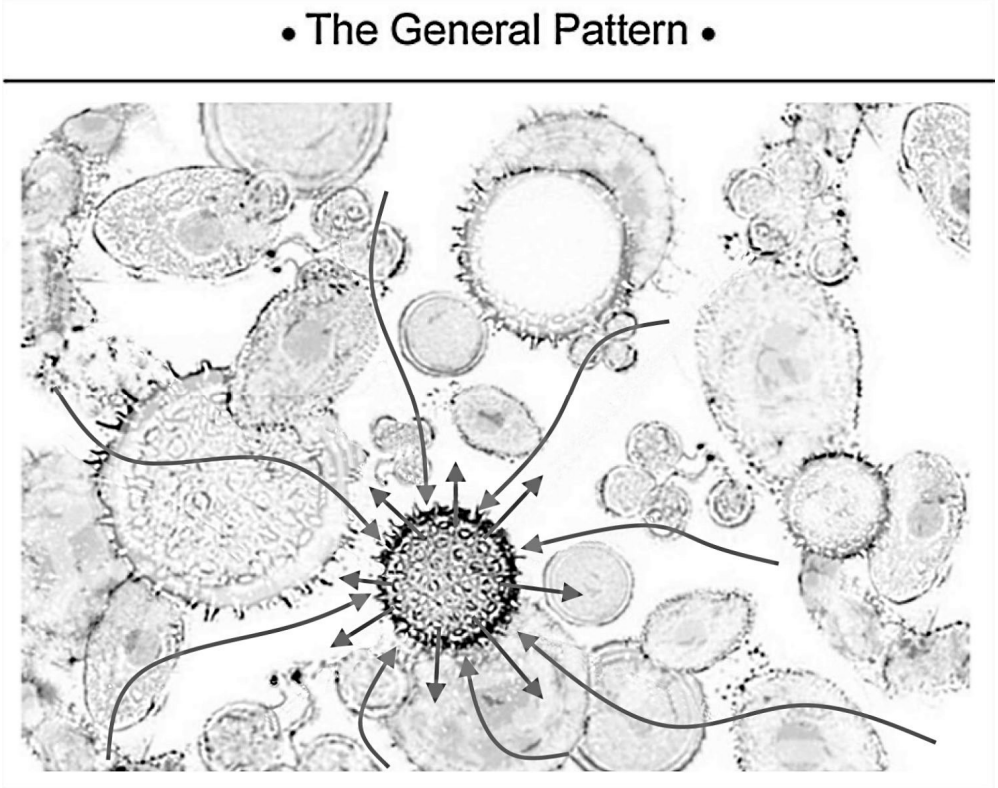

Fig 9. Growing cells in open mediums of exchange

Where one's understanding shifts to a still higher level may be from recognizing the kinds of continuity and discontinuity in the general pattern of environmental organization (Fig 9). There are four general kinds:

1) The *continuity* of growth and development of whole individual systems, such that all parts are integrated with the whole, exhibiting continuities of change as in Fig 3 and 4.
2) The *discontinuity* between individual systems that remain independent as they interact.
3) The *continuity* of the open mediums of exchange within which networks of individual systems operate.
4) The *discontinuity* of design found in unexpected breaks in continuity.

The general pattern of environments is illustrated in Fig 9, representing all kinds of individually organized natural systems as a host of differing individual

cells depositing and withdrawing products from the common environment they co-evolved to exchange beneficially. Each system is defined by its internal design and role in the common medium. The actual paths of exchange between systems are hinted at with dotted lines. The real environment has more extended hierarchies of cells and mediums of exchange, such as - humanity, the economy, businesses, people, organs, cells, organelles. These nestings are *not* mutually exclusive, in that people are individually part of the economy and part of businesses too. So the natural system network is "not a tree" but a "semi-lattice" (Alexander 1965), designed for opportunistic connection, not logical rules.

In looking for where to apply this method, you might start by looking for where things in an environment are not well served, and examine the context for the continuities and mediums of exchange related to it to identify the boundaries of what the problem might be. Not every problem should or can be solved, but solving things often involves finding new ways things can work together, making some careful addition or subtraction that changes the design. Virtually all good relationships seem to come from finding transformative ways of connecting opposites, like the shaking of opposing hands or combining the work of an artist and a manager. Sometimes it takes suspending or redirecting existing connections to introduce a new pattern, like inserting a new role, so connecting parts have more freedom, letting all the parts pull together, bringing living quality in one place that spreads to others.

3.1.4 Exploring Mediums of Exchange

In looking for a fully satisfying way of responding to some need you might first clear one's thinking and explore its context with "fresh eyes," as if first browsing the pages of "book zero" for seeing what is there without judgment. If one avoids making assumptions, one is more likely to be guided by some neutral pattern, reading the whole situation without interpreting it. There are many ways to do that. For example, one might first look for all the kinds of "boundaries" they can find in the context, as a non-interpreting way of seeing what is there. "Boundaries" is Shape #3 in Alexander's 15 common patterns associated with "wholeness" (Table 4). These spatial design patterns depict very recurrent shapes and natural forms. One could use any of them as search patterns for developing a neutral perspective of a small or large context. Then when one turns to explore

options for design that reading of "book zero" leaves one with a rich collection of environmentally connected markers with which to work.

Another way to explore an environment without judgment is with a moderated group process that developed from my work at the UN, called the "3Step Process for Working with Nature" (Henshaw 2013). It begins with picking some shared ideal or principle the group is passionate about, such as 'equality,' 'integrity,' or 'freedom,' or a natural design pattern like "mediums of exchange," or "centers." After generalizing the ideal, the group uses it to search a relevant context to bring cite cases they find affecting their ideal.

Surveying the whole environment expands the group awareness in several ways. If some take turns speaking about the cases they see, others can take turns writing down speaker observations, and add their own to expand on and record the process. By sharing each other's neutral observations of conditions affecting a group passion leaves everyone with a "big world" view, and able to freely associate the observed intricacies of the environment is relationships, ready to suggest ideas for responsive design or take other directions.

Environments are themselves "mediums of exchange," I also call "resource pools," vast storehouses of mostly potentially useful materials, and also patterns of design that future living systems might follow. Table 1 lists six general types and some instances of each. It is surely an incomplete list. To understand it perhaps a reader could add two or three that I missed. The table is mainly for drawing attention to the physical locations and roles of these unstructured structures of this other half of life.

Table 1. Some common mediums of exchange

Types of natural systems and associated mediums of exchange	User explored	User Harvested	User Supplied	Nature Supplied	Cultural Exch.	Circulating flow	One way flow	Producer Supply
1 Material Resource pools								
a - Landscape, Forest, Society	x			x				
b - Atmosphere and Waters		x		x				
2 Material Resource Flows								

a - Trees, Plants, Bloodstream				x		x		
b - Parties, Family tables			x		x	x		
c - Rivers & Streams		x					x	
d - Production, Economies							x	x
3 Central Hubs as Hives								
a - Producer markets	x				x			x
b - City terminals and docks	x				x			x
c - Business Workplaces					x			x
4 Local Hives as Hubs								
a - Nests, Homes	x		x		x			
b - Toolshed, Pantry	x		x					
5 Larger Hives as Hubs								
a - Social and Business Ctrs.	x		x		x			
b - Social & Political Ctrs	x		x		x			
c - Open Markets & Bazaars	x		x		x			
d - Schools	x		x		x			
6 Transient Internal Sharing Hives								
a - Picnics, Meetings, Huddles	x		x		x			
b - Auctions, Fairs, Parties	x		x		x			

The mediums of exchange that natural systems use as resources seem to be the principal foundation of all naturally occurring systems, relying on byproducts of prior systems, consisting of both “raw materials,” “seed patterns.” It makes them one of the more useful environmental structures for studying the systems that use them, consisting of byproducts from prior systems scattered about in their environment located “in-between” other systems as part of the common pattern (Fig 9). Table 1 organizes a partial list of naturally occurring systems and their types of mediums of exchange. It largely lists external resource pools but also included the two internal resources pools illustrated in Fig 10, the communal food sharing around a circle and the internal circulation of plants.

The family table or park blanket around which friends or family pass prepared dishes and pitchers of refreshment serves as a circulating resource pool pass all the goods by everyone, much as the internal flow of products and resources of a tree or other plants. The “leftovers” of the picnic will be partly used in later meals, composted, washed and returned to their place and the rest sent to be recycled or buried. In preparing a picnic, every expected need is typically first brought to the

table and then passed around (or across) the table to those sharing in the meal, and later all cleaned up, and all evidence swept away.

The degree of collective effort varies widely, from pot luck meals where everyone contributes equally, to family gatherings where each person exercises their role in the family. Whether small or large, or whether providing the food or life of the gathering, generally all participants have essential roles in the gathering, unless it is all done by a catering team. This general pattern of variations can be found for lots of other kinds of meetings, large and small, with the rules and standards of one useful for others too.

The bloodstream and economies are examples of far more elaborate "circulating resource pool" designs, where the channels of circulation connect all the parts delivering raw and refined products and collecting other refined products and wastes. The commons principle that what is best for the whole is best for the parts seems displayed for the flow of blood to all cells in the body. It seems also used by the cells of a body responding to deliver what the body needs, and so demonstrating what is evolutionarily sustainable for the growth of natural systems of energy using parts.

The economic system and its flows of producer and consumer goods and activities may be roughly similar in complexity to that of a human body, delivering raw and refined products where they are needed as they also generate wastes all along the way. An economy certainly follows different principles for managing its flows, though, giving the highest priority on concentrating wealth for a few. You see that in natural growth systems too, but only at the early growth phase, the sensible economic plan for startup systems or businesses, that maximize the resources devoted to getting started.

• Internal Mediums of Exchange •

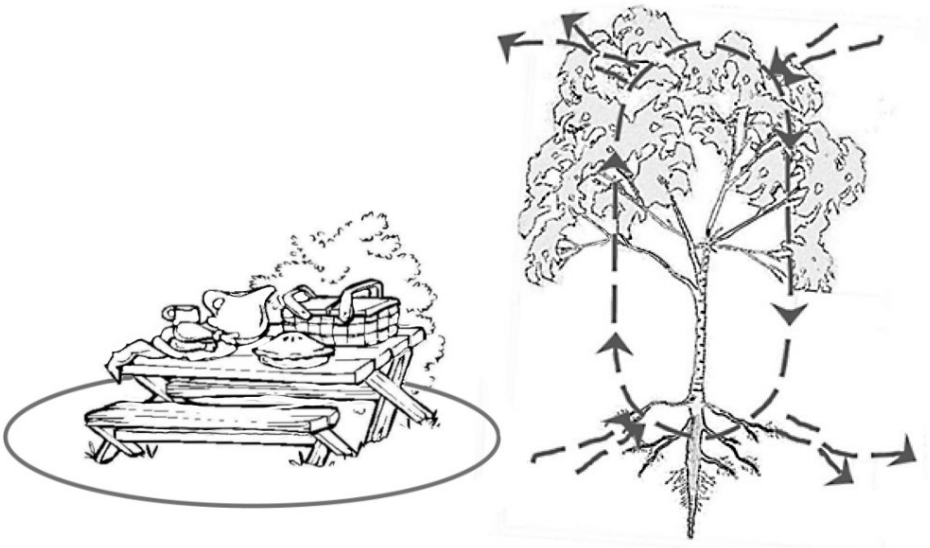

Fig 10. Circulating resources pools; a picnic and a tree

Natural mediums of exchange are sometimes recognized from the cultures that swarm to them, creating a center for the cultures of living things, like a town square or places that support ecosystems such as freshwater ponds. Such places are adapted to by the cultures that live there and telegraph to future generations the former ways of life. A town's buildings, institutions, and arrangement of mediums of exchange co-evolve with its cultures, form a persistent design pattern for the character of life in the town, a historical artifact that future occupants build upon. That historicity of design that adaptively extends the early persistent patterns into the future appears to be the main reason growth systems perpetuate their earliest designs, in that they are functionally developed from those earliest roots.

Because of how towns are generally organized as a whole, with any gap filled and its uses naturally clustering together, the 'wholeness' of such a design tends to survive the removal of even important parts, by its absence provides a template for an adaptive replacement, first observed by Alexander (Henshaw 2015d, Salingaros 2017). All growth seems to be a system of extending prior designs, an unbalanced process of endless expansion at first that can change to perfecting the original plan or fail to. How persistent a pattern of design is over time would could

vary, but the often noticed persistence of the original character of people, places and organizations suggests that much is generally also retained.

I often emphasize the study of natural systems from a view of their stages of growth (Figs 3 and 4), and how the internal expansion and design is their life story "where the action is" of first expanding on small scale origin to end up refining the design they develop to a point of perfection. The study of mediums of exchange seems to be somewhat the opposite, a study of "where the action is not," of places where leftovers from the past collect. As discards they might settle in various nooks and remain detached from the active systems of the world until they are picked up to be a resource. Of course, the world of nature's scattered pools of unattached resources is also the external world of the growth systems of the world, as where they go to get resources, so the two are thoroughly connected.

Drawing the dichotomy that of the self-organizing world of natural systems (syntrophic behavior) and the scattering of disorganized parts of prior system (entropic products), is important to highlight. The two are forever tied together, both as resources for new systems to use and leaving environmental footprints to guide the development of new systems. That is also evident in how plants scatter pollen and seeds as well as how one community's niche fits into a pattern with others and becomes the new niche new residents as time passes. It makes for two types of natural order, "cells" and "in-betweens," where great varieties of things collect quite unattached. So they're not "systems" in that sense, even while playing very important temporal connections between systems.

Plantlife, of course, seems to be the prime example, of co-evolution with complex soil life, with underground and surface species tending to develop in directions that foster each other's growth. We also talk of a business, culture or a person as being "deeply rooted" too though. The preceding should now give you a better sense of what that means ecologically, and a way to begin to translate some features of natural design to human concerns.

3.2 Discovering Patterns Of Transformation

Learning to read environmental changes from data trends and maps is much more easily and usefully understood if those indicators are first read for the stories they tell. It takes a little experience but that stories of change follow arcs of rising

and falling action closely related as those of systems of change (Fig 3, 4) provides a good start. Today it seems that even ancient cultures and environments are going through ever-faster change, learning to watch it happen is very likely important to do. Rapid accelerating global change is one of the natural side effects of both overextended economic growth and the chain reactions of change in natural systems it initiates. At the limits now being crossed it naturally produces a kind of organizational panic, with every kind of organization in the environment having to juggle changes ricocheting around the world. Becoming fascinated changes taking place also fosters one's ability to observe what is happening, notice its connections, and the options for responding to them.

3.2.1 "Pattern language" as a proxy measure

Cultural and economic trends can sometimes be usefully studied using the 2010 Goggle 'Ngram' app for displaying trends in the publication of one, two, and three-word phrases found by scanning the collections of major libraries.[3] The interest is in how those trends of word use display the dynamic shapes of culture change, seeming to provide a sometimes clear and sensitive "proxy" indicator of societal and environmental system evolution. For example the trends in print of the term "pattern-language" (Fig 11) seem very telling. For the story it seems to tell to be useful requires careful interpretation, which is where learning to recognize patterns of system change comes in. Both the curve for books in English and German show a familiar growth curve shape, an overall pattern of "progressive proportional change," at least from ~1985. There is also an earlier period of dynamic growth in use, both seeming suggestive of emerging cultures using that term. To treat the Ngram data source as scientific evidence is quite hazardous, however, and not having data to beyond 2008 very limiting for following ongoing events.

In any case, working with proxy measures requires repeated validation of apparent trends, varying the story and checking it with facts, new data, and other observations. That defines this kind of work as a type of forensic research. Talking to people familiar with the history or looking at related trends and mining other

[3] Google Ngram Viewer for historical one, two and three word phrases, 1800 to 2008. https://en.wikipedia.org/wiki/Google_Ngram_Viewer,

data sets and articles all help "flesh out the story." The history curves in Fig 11[4] give clear evidence of roughly matching long term growth-like progressions, with no prior use of the term at all. That is strong evidence of related emerging English and German cultures using the term. Seemingly coupled emerging cultures like these would leave behind other evidence of the systems producing them, like the departures from the overall trend.

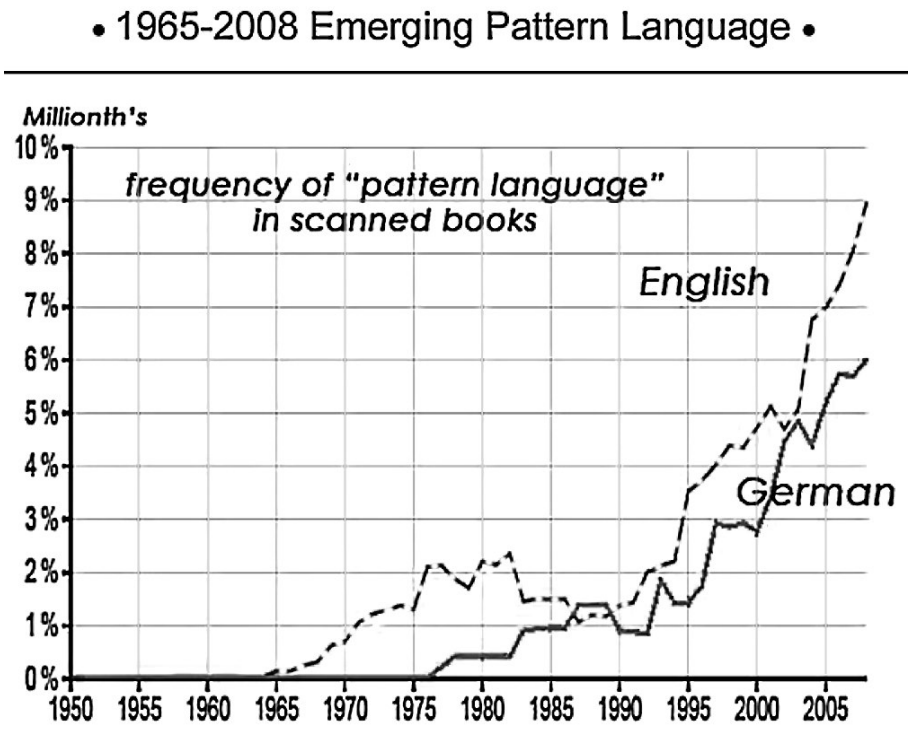

Fig 11. Growth patterns showing organic emergence[4]

In Fig 11 it lets us see differences in how the discussion of pattern-language developed in English and German language communities, providing an added dimension to the evidence. The two curves end up following about the same explosive growth trend from 1990 on, with the curve for English showing rise and fall in the frequency, a wave that peaked at ~1980. The German trend shows a smaller delayed wave of similar shape with the peak at, ~1987. The differences make sense if one notices the German trends began a little later and have the same shapes as earlier English trends, with the original breakout of pattern language being in English schools of urban design and architecture. That initial interest

[4] Combining 1950-2008 Ngram plots for "pattern language" for English and German

seems to have peaked after about 15 years from the beginning in both cases, followed with a longer and stronger second wave in each. All those features fit with the breakout use of pattern-language for software development in the late 80s in a new form, also more adaptable to other design cultures, as it spread to a much larger community.

If you accept that interpretation of the linked growth trends, the curve does seem to be a record of a transformational culture change, passing the test of teaching us a variety of things we would not have known about otherwise. The two records of change as responses by two different communities, having related different shapes fitting a common pattern, consistent with local cultural differences in joining the same conversation. The importance of this discussion is as an example of the rich value of "found data," identified by the dynamic shape of emergent systems, telling a story that could be further studied. The data was picking out shapes of this kind form the flood of new data sources now available, demonstrating one for the new uses of "big data."

Found data is a common source of discovery for unexpected change taking place, nature not announcing what she is doing any other way, with the early stages of happening quite hidden from view. Emerging systems generally have a slow start at small scales, invisible in the noise of other events, as their new centers of organizational development become established. The shapes of the two curves are similar enough to suggest they are parts of the same emergence, the two curves both having a doubling rate of about 7.5 years. That indicates a coupling of the two curves, the English curve having a little head start. If we had other knowledge of what was happening, we might find how other professions are picking it up. Growth curves are generally also proxies for the growing scale of energy use and money invested, so there are a lot of things a systemic change of this kind would affect that might be studied.

Rates of word use can be tricky to interpret, of course. An increase in word use falls off even if the associated change continued but just was not news any more perhaps. Of course, a minor spelling change or a switch to using an acronym in favor of a phrase would also confuse the data. So as elsewhere, what you're looking for is not "data," per se, but "better questions," data that teaches you something provocative that analysis could not. That is the real benefit of using

"data continuities" interpreted as "storylines" for interpreting organizational developments, built piece by piece with a forensic inquiry.

3. 2. 2 Big Data

Discovering what is happening in one's environment might be somewhat automated, using algorithms for recognizing emerging systems and their transformations in the mountains of free data of all sorts now available. Though widespread work with big data has been occurring for a decade in other areas, though it is hard to find applications for recognizing developments in environmental change. Older papers on "time-series interpretation" are still at the top of Google Scholar citations. Pattern recognition of emergent environmental change could be roughly the equivalent of polling mother-nature on her current interests. It would expose lots of things people would like to know, speeding up the work of understanding what is changing and how to respond, alerting scientists and journalists on where to look for tomorrow's news. The interpretation would still not be automatic, of course. My own early work in the area (Henshaw 1995-9, 1999) could be a starting point, along with recent groundbreaking study of the precise timing of trends of climate change (Henshaw 2019). Ways of teaching pattern recognition of this kind, and using workshop methods for accessing the insights of people involved with it have also been proposed (Henshaw 2013 2014).

In addition to the wealth of economic data from national accounts, there's a flood of data in the form of "community indicators" and "comprehensive sustainability reports" for city and business sustainability reports becoming available. Combined with commercial data sources, the potential resource is enormous. Of course, libraries, research centers, and governments are all actively developing new ways to use the flood of data already. The UN has a major worldwide data collection and coordination effort for the Post 2015 sustainable development plan. That includes a focus on collecting a broad spectrum of information on what is generally called "ESG factors," for monitoring interrelated environmental, social and governance conditions worldwide. The interpretation of data still largely relies on isolated statistical correlations between numerical "goals" and "targets," treating societies as working by numerical pushes and pulls between categories we define for them. The UN's statistical programs and

innovative Data Revolution council[5] , as well as civil society organizations and others, are trying to invent marvelous ways to use all this data.

The paradigm shift to using growth and decay curve recognition to find whole emerging systems to study seems not to be happening, though, despite wonderful continuing work on statistical patterns. So much work remains to be done to reorient the scientific pattern-search toward revealing the natural systems with which we need to work. That would take first developing a curiosity about natural systems, as a motivation to serve. One would rather not rely on the plans of business interests maximizing their profits, which science is very heavily involved in supporting.

3. 2. 3 Locating Centers by Their Boundaries

We all become expert in recognizing boundaries, like between the sidewalk and street, or entering some private group's conversation or some unfamiliar culture's neighborhood. We quickly notice if we're approaching or crossing them, often tipped off by a gut feeling of either caution or anticipation that tells us to think of acting differently. Then we realize we should think of changing behavior as we approach. It is the well-tuned environmental alertness we all have, that prompts us to sharpen our senses and look closely for signs of what to do next. Our response may be to open up and become engaging, or it may be to expect threats and be more alert to danger. What those signals are are responses to is our entering someone else's home territory, crossing into its 'niche,' and "private space," or "back yard," their peripheral space that mediates the separate worlds within and without.

You can think of the general pattern in terms of walking through the woods and coming across someone's home (Fig 12), unaware of people or animals but seeing it as a well-maintained place. You probably would not approach to say hello unless you needed to. But coming across a boundary and being curious you'd look for where it goes, and for signs of how the relationships differ inside and out. If you had a question, perhaps you'd judge whether you'd be comfortable walking up to the door or had better keep to the fringes of the yard.

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[5] UN Data Revolution panel: http://www. undatarevolution. org/

Fig 12. Centers surrounded by niche boundary zones

If the home looked well kept, and one did really need some help, you'd look at details of the entrance for hints on how to approach the door and get an idea of what response to expect. We might stop before knocking if we noticed signs that the resident is not home. We might see the shades are drawn, the patio unswept and the plants on it untended, realizing it must have been a hired service that recently mowed the lawn. Much the same sort of encounter may be experienced approaching a strange vendor's stall at a green market or crafts fair. We read the signs the same way, noticing details to see if the stalls are more or less well-kept and if the vendor might be receptive, reading all the odors and visual signs.

As you approach, you may be encouraged to come close, drawing into the vendor's private space, still needing to size up how to interact with the vendor. Crossing into someone's personal space is a matter of presence, little ceremony, like a handshake. When you make contact with others, you ideally want the timing to be right, and for both parties to engage in the greeting together, it is a little ceremony using a mutual homing device to synchronize the contact motions. Those same fine details of negotiating boundaries might be faced anywhere messages need to travel from one domain to another.

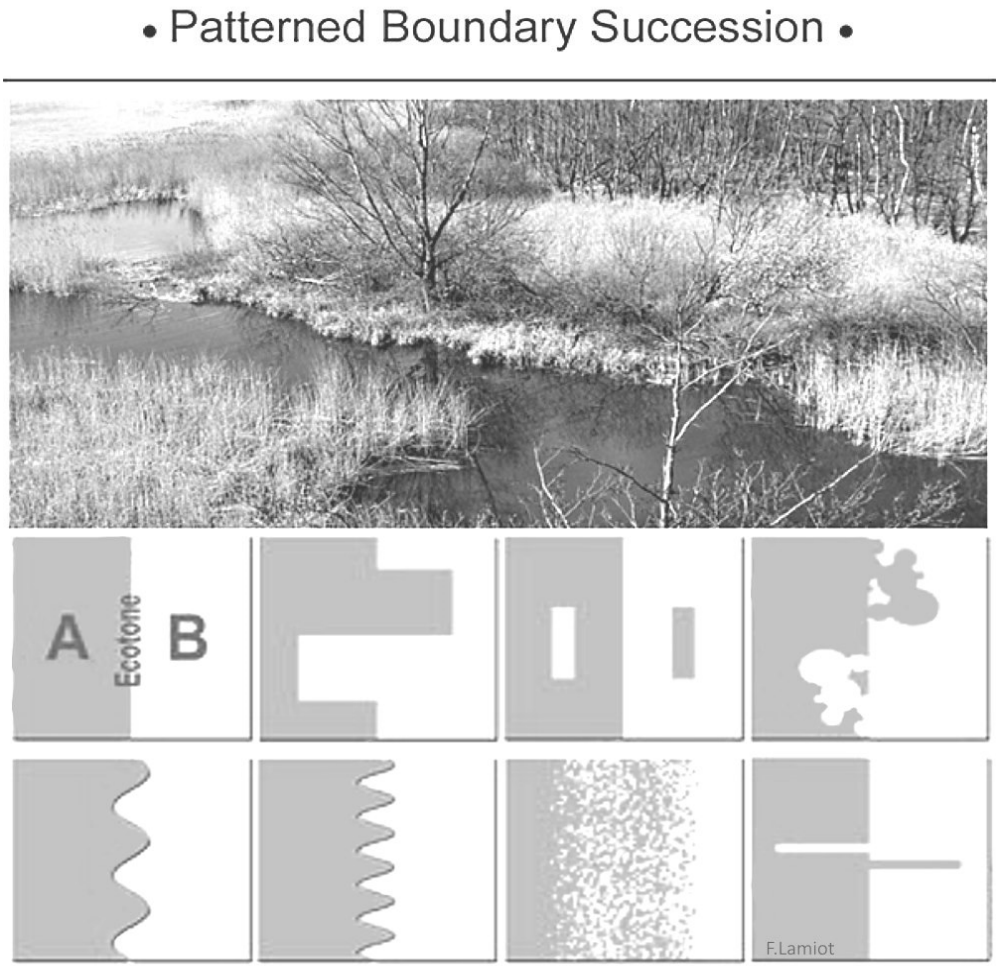


Fig 13. Centers found with diverse ecosystem boundary types[6]

The natural shapes of ecological boundaries are fascinating and hard to define, but once noticed, are often easy to pick out (Fig 13). We learn to be expert in reading them too, anywhere there's a "territory," it is likely to be filled with boundaries that define separations between one culture or domain and another. You find them between industries and business cultures. The variety of shapes one finds in all kinds of natural spatial boundaries are generally similar. Fig 13 shows one collection of geometries characterizing natural boundaries, these drawn for plant ecological zone transitions. They're complex and overlapping yet as distinctive as the signatures of people, both rather hard to explain but distinct and easily recognized.

[6] Wikipedia – Ecotone - https://en.wikipedia.org/wiki/Ecotone

3. 2. 4 Following the energy

Locating centers of design is often a matter of locating centers of energy use, located by following the traffic to and from them. The “desire lines” of trails across a snowy campus show where the foot traffic goes, and “where the energy” is. They’re much like the pheromone trails that insects follow to a new food source. That is the basis for the idea of “stigmergy” too, thought of as a programmable model for how behaviors develop following trails left by others returning from someplace of interest. Energy uses leave traces behind of many kinds, as artifacts of what the energy was used for, leaving trails to trace to their sources. In the case of economic energy uses, the trails of energy use eventually lead back to the homes of families and communities where the knowledge and organization for getting and using energy are centered, for example.

Patterns of melting snow on the roofs of houses show interesting signs of energy use but may not show much about the family inside those houses, whose lives are the energy source. The evidence of energy use is only of where some such culture is located. That tells you little about the generally hidden internal life of the homes, either how use energy in the home or of the means and knowhow for going out to get more. You’d learn a little more looking at all the other signs of the culture a group of similar homes, the kinds of shops, public and private space, travel and other artifacts of how a community that connects the homes lives.

The money people bring home is a direct proxy for energy resources too, as are the products of energy use brought home with it. So money use can let you trace where society puts its energies of all sorts, in a far more truthful and inclusive way than the stories we tell. The homes of its families are arguably society’s largest infrastructure and capital investment, where people both bring and enjoy the end products of using energy and exercise their own culture for how to enjoy products of their energies. There’s a reason for that.

The energy invested in homes yields direct returns to the economy, enabling the occupants to go out and bring back money and goods to sustain their home cultures and the world. It makes homes of all kinds the real energy centers of a society, where both the flame of hearth and home are nourished and the productivity for society in nurtured. A healthy home then contributes its energy to enlivening surrounding centers of the community and culture too, in both direct

and metaphorical senses. Being so private and hidden from outside view, our homes remain largely protected from any invasions of privacy, or judgment, as they empower the world.

The main reason one pays attention to energy is to make sure one has enough, so for budgeting reasons. Home and business financial budgets have the function making sure more money is coming in than going out, of producing for greater returns than expenses, and very helpful to be thought about as an energy budget, at the present world average of 1.25 kWh/$ GDP. That means our economic budget burns the equivalent of a 1,250-watt appliance for an hour, on average, to produce any $1 worth of goods (Henshaw 2011, 2015d). It is shocking to think how very much energy the economy needs.

To budget for the world economy's energy use, one would hope to find at least as many $1 expenses that produce an excess of 1,250 Wh of energy. Beyond that, any business plan needs to use its energy to serve the many stakeholders of the economy, including all the new costs it has failed to budget for pursuing endless compound growth on a now crowded planet. Still, the basic "design pattern" for an economy, or business, or family, is to spend energy in a way that generates enough more energy to pay for enjoying the way of life. The trouble is the expenses people care about and campaign for are the type that result in no energy in return, forgetting what the business model requires. That is a perfect design or bankruptcy, continually adding to overhead and neglecting infrastructure, that we have seen building up for decades. It is a good example of what a pattern-language business model would try to address, starting from a neutral view of the context and telling the whole life story.

3.3 Pattern Writing Templates

The usual way of describing design patterns is with a concise statement covering its place in a complex world and how it is made. One collects 1) diverse observations on the conditions, 2) particular forces to be resolved, 3) identifying a simplifying ideal for resolving them, and 4) a the means of doing it, 5) giving it a suggestive name and visual image. The focus is often some gem of expert knowledge, or way to achieve some natural change of state. Leitner (2014) and Schuler (2008) describe styles of pattern description using stacks of cards for group discussion. Table 2 shows a general template for technical pattern writing,

for use in any field, with an image of "back and forth" a very common part of natural system designs, the template based on the model of Iba (2014), to include:

1. A suggestive name, and characterizing image
2. The circumstances where the design would apply,
3. The unresolved 'forces' to be balanced and resolved
4. A problem or untapped opportunity presented
5. The unifying response that satisfies the whole,
6. The actions to take and outcomes expected

In practice, forms like these might have a little more space for text but kept very conceptual, perhaps linked to other documents or intended specifications and narratives. Every situation will require a unique response, of course, so the design pattern itself is just a guide to how to use an ideal principle. The best designs are still context-dependent and often counter-intuitive too, requiring a new vision for the place and its forces. The realization may not be easily duplicated in another too, all dependent on finding ways for fulfilling the ideal.

Table 2. A Template for Design Pattern Writing

<table>
<tr><td>Name</td><td>Context</td><td>Forces</td></tr>
<tr><td rowspan="2">Image
  </td><td colspan="2">Problem</td></tr>
<tr><td colspan="2">Solution</td></tr>
<tr><td>Subject</td><td>Actions</td><td>Results</td></tr>
</table>

If it is reasonably well-validated and does not produce the expected emergent properties, there should be some clear reason. For implementing a design, the design pattern is just a place to start one's learning about the actual circumstance addressed, having identified an apparent pattern match with its needs. Learning how to satisfy the needs of the real situation may then be either simple or complex, take minutes or years, depending on what kind of organizational transformation is involved. It is a process of learning from the real context and its actual forces

to find what they will respond to, that produces the final fulfillment of the pattern design.

Table 3. A Template for Natural Pattern Writing

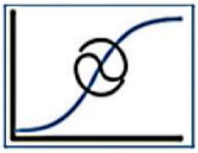
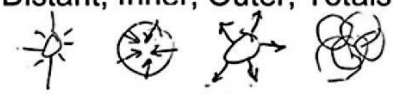
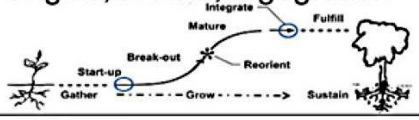
<table>
<tr><td>Name</td><td>Problem</td><td>Forces</td></tr>
<tr><td>Image
  </td><td><u>Context</u>
• Scales & Centers
• Roles & Partners
• Stages & Events
• Movements & Ties</td><td>Distant, Inner, Outer, Totals
 
Origins,Growth,Intgegration
  </td></tr>
<tr><td>Simplifying Relationships</td><td>Object</td><td>Solution</td></tr>
<tr><td>Links</td><td colspan="2">Anticipated Results and Open questions</td></tr>
</table>

Table 3 is an expanded template for describing naturally occurring design patterns. The main difference is needing to describe the emerging development process that occurs as the emergent individual did or might develop. For naturally occurring designs development is a natural process of self-organization, what takes the place of the "designer." Describing it includes identifying characteristics of its stages of development, origins, divergent growth then reintegration within the context, and as noted in Figs 2, 3 & 4. The stages go by the terms "germ" or "onset," followed by the initial "startup" period, then increasing scale with the "takeoff" to then reverse directions and turn at the midpoint "pivot" toward perfecting the design. That takes it to "landing" and its normal end in "fulfillment" and "autonomy" for reintegration in the context. All are depicted as stages that have already or might occur, for which needs can be anticipated, and renamed as appropriate.

You'd seek to relate the stages of development and their names to the changes in organization at each stage. The stages of transformation for natural systems generally follow a pattern like architectural designs, of immature and hesitant growth in the "startup" period. That is followed by increasingly systematic growth that switches from expanding scale to introducing refinements to the

design at the “pivot” mid-point. That continues with more mature and refined development taking the “landing” phase to he climax of growth at the point of “fulfillment” and “autonomy.” Each stage along the curve would be associated with step-wise changes in organizational development, each one the foundation for the next as a pattern accumulative design that gets somewhere as the growth progresses from level to level.

For a design team applying a pattern, there are numerous models for “action learning,” the most ancient being the design studio method of every individual pinning up their work and engaging in a group discussion with stakeholders, each working independently on their ideas for how to advance the group objective. A modern method for achieving the same end is “agile design” and SCRUM for software development. Its organizing principle is like fast-tracking the ancient studio model, but around delivering testable product for every scheduled design review.

From my work, a learning cycle that could be used to augment any action learning process was developed to include an cyclic sweep of the project knowledge to follow each the design review. It is applied as a 4D principle of design, each cycle of design ending with a review of the 1) Internal and 2) External relationships of the design 3) Distant, connections, risks, and purposes and 4) looking at how it all adds up for a Total Balance of its tradeoffs[7]. That accounting for tradeoffs would include accounts of resource dependencies and energy costs. The whole cycle of self-examination starts rather simply and develops holistically with the rest of the design.

3.4 Great Repositories for Natural Patterns

One of the more surprising discoveries when applying Alexander’s idea of design patterns to patterns of naturally occurring design is how many rich repositories of natural design patterns there are. It is inherent in nature, as an aspect of entropy, to leave traces of everything that happens, both simple and complex. Some remnants are like echoes of the past others like a compost pile or junkyard are composed only of fragments. Then there are the working design

[7] Henshaw- 4D Sustainability http://synapse9. com/connection/

patterns of the systems of nature themselves, cultures especially, that contain copies of their genetic codes along with their working organizational designs. That would include the networks of relationships and practices that organize our own lives around its rituals, the “night out” or the “day at the beach,” “school,” or work, etc. The environment is a particularly rich living pattern repository for cultures and ecologies.

Human cultures are the living storehouses of all the learning we inherit and build on, containing all our accumulated ways of knowing and living, offering endless reminders of the tricks we might not come upon during our whole lives if not reminded by bits of ancient wisdom and practice. One could even define a new meaning for ‘culture’ that way, as the living design pattern of each species’ shared experience of life. Cultures are a living memory and way of reproducing a community’s total experience, with surprisingly ancient roots. Today we still learn from traces of lives lived a million years ago, and we still have much to learn from our current way of living to record in our culture for those who follow.

Nearly every person knows a great deal about their own culture, by “osmosis” it appears. It seems to make acculturation a great resource of recorded natural patterns, as automatic responses to common experiences associated with clusters of familiar meanings. Of course, maybe more than anything else we all tend to take our own culturally inherited knowledge for granted, as we perhaps should, even though it also blinds us to what else can be understood.

3.4.1 Cultures as Stores of Natural Patterns

The natural patterns we know of from our cultural inheritance are quite difficult to stand apart from, to either critique or compare to others; they are so deeply rooted in our thoughts and feelings. They’re often “too close” to recognize in that sense. It is a source of miscommunication that much of our tacit knowledge and ways tend to be hidden from us that way, left out of our thinking about how we might affect others. So using one’s culture to discover more explicit cultural connections with natural designs can be both a pleasure for awakening and refreshing long-held assumptions, familiarity with the real genius of their sources perhaps. It can also help one discover the genius of other cultures. In other cases hidden patterns of our cultures as deeply rooted offer renewed security, as well as to help one live down perhaps some serious discovered mistakes.

It is curious how unaware people are that their own cultures are among the most ancient organisms on earth, perhaps as old as species, their intricate designs built up silently over the centuries. Our cultures do contain all our ways of living and knowing, though, without which no book would have meaning. Somehow there seems to be a highly evolved complexity wrapped up in our every gesture and thought, its environment reverberating with it. Individual expressions of people in one culture seem both as individually unique as if from different species as well as to display the recognizable patterns of every expression of others in the culture. Open connections between cultures appear unexpectedly often enough, though, with moments of empathy during shared experiences. Changing one's culture, though, seems rare, like grafting a plant onto new roots. That will not bring the roots along.

Bridges to connect differing cultures can be found by more practical means too. One is by comparing independent observations on the same naturally occurring patterns of design. It can add to the richness of the meanings of the pattern to combine different perspectives of the same thing that way. Combining different views often adds useful perspective, critical for getting things to work too. I mention it here not because of having some neat way to make that easy, but to mention the possibility that natural patterns can help us cross divides.

Just being attached to certain styles of expression can keep us from listening to unexpected views. People also invent styles of expression to use as code to hide their real views, defining walls of separation like accessed only with a password, that only those in some circle will know. That is a pattern that seems to be present in keeping the fabled "six blind men" from being unable to describe "the elephant." They are prevented from communicating with each other by each one abstracting the elephant as being the code they invent for it. It seems to be a very common cause of intellectual confusion and the human inability to act in crises.

How much of this cultural foundation of how we know and live is deeply hidden from our view is expressed in Fig 14, showing a range of visible and hidden aspects of human cultures. It adds to the richness of the heritage to expose it, and study its roots. The majority of it consists of tacit understandings that are quite unconscious, very vital and active but unspoken and hidden, with only surface features exposed like the tops of icebergs. Though people speak a lot and use words for all kinds of communication, the real foundations of our knowledge

and ways of living seem largely in non-verbal experience, and well worth exploring.

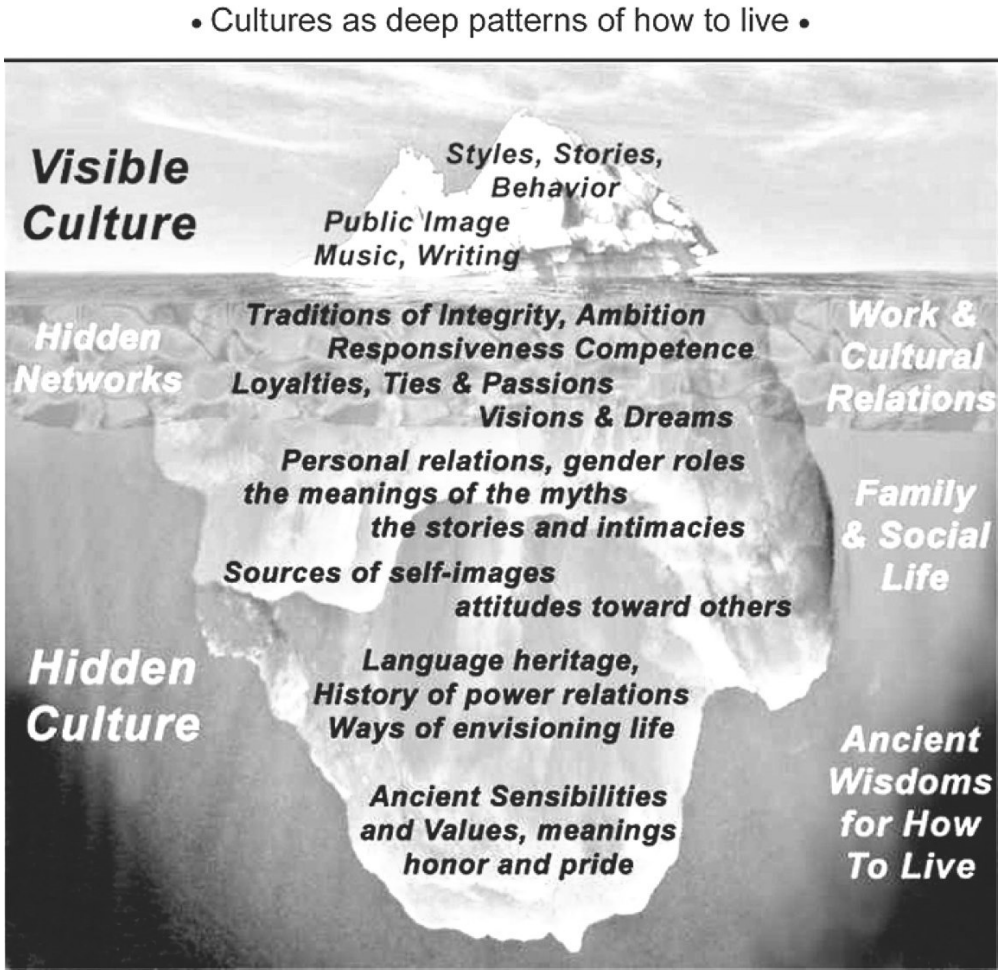


Fig 14. Our cultures store all our ways of living & knowing

So this list of the visible and hidden natural layers of culture is hardly complete, very sketchy really. We do not have any explicit record or statement of what a culture is, except that it is the root of everything we know and every way we live. Cultures are remarkable living "artifacts" of lives lived and shared over time, easily more complex than our genetic codes, retaining patterns of relationships, lived by others, kept alive for ages and always open for accumulating new variations too.

3.4.2 Natural Language as a Pattern Repository

We tend to take the meanings of words; our articles, nouns, verbs, and adjectives, etc., and their many interrelated semantic meanings for granted. All would have no meaning though were there no life experience to refer to. If you think about the conditions of ancient human life, it appears our words would have come from connecting sounds with natural experiences, especially those with cultural meaning, slowly identify sounds with the design patterns we found most meaningful. Sometimes a shared experience would be communicated with quite sounds and sometimes loud, that with habituation turned into words. In a sense all would associate animal or imitative sounds, in myriad differentiated ways with recurring experiences. Take the word "noun," for example. Without words that name things, the word 'noun,' referring to the "naming words," would not have much meaning.

As a result, language is a rich natural resource of associations with natural patterns. Any word in a sentence can be explored this way, by pausing to mentally search for all the natural experiences it is associated with, to kind of map out its root associations and meanings. It might be a word noticed for having some unknown pivotal meaning. It could be a word central to a story, or one arising in a circumstance you want to understand. Searching through its associations could well expose the hidden meaning, to be enlightening and helpful.

Another pattern writer, Takashi Iba, uses a similar technique. He draws on what he calls "center words," particularly evocative words found in pattern descriptions to help with his search for images to illustrate design patterns (Iba 2015). Those keywords are also likely to be associated with rich experiences. A good dictionary is, of course, also a good resource for learning more about what natural experience a word recalls and gets its meaning from, exposing the significance of the natural design patterns that proved memorable.

I use the tracing of words to their root meanings and experiences for several purposes:

1. Finding common ground in discussions by connecting the subject to shared patterns of natural experience.
2. Exploring the "center words" of mission statements, such as for interpreting design patterns and their root meanings fit together.

3. Exploring the structural connection of word meaning opposites, so often producing valuable emergent properties, such as combinations of "compression and tension," or "rigidity and flexibility."
4. Finding useful roles for people, places and things by looking at diverse examples of similarly found connections
5. To find combinations of familiar words to associate with unfamiliar natural patterns, such as I have used the terms: germ, onset, takeoff, pivot, landing, fulfillment and autonomy to describe the stages of emergence in natural growth.

In either direction, whether starting from words to find the root experiences that give them meaning or from starting from root experiences to find evocative words for them, one would use pattern search. The most fertile ground seems to be the most ancient words, naturally, as the words with the most ancient meanings and deeply rooted modern usage. You might look at all the uses of the word "apple," a particularly ancient and attractive fruit. In Greek mythology, it became a symbol for knowledge, immortality, temptation, sin, and the fall of man, and associated with the unnamed fruit in the story of Adam and Eve[7]. The value of apples recognized in Celtic tradition as a delicious treat that could be polished like a gem associated it with good luck seem and special gifts, consistent with modern usage like "apple of one's eye" to represent the highest' of ideals[8]. Another good example is the word "road" which has multiple uses like "the high road" or "road to ruin," and many others, which seem closely associated with the meaning "journey" as travel to the future, where the uncertainties of risk and reward are present at every step.

For example, on this journey, into the root meanings of words, it can be particularly rewarding to study families of words with related meanings. That has the effect of taking them out of their normal context, so their individual meanings can stand out as variations on a common theme. In English, the many families of compound words are great to explore this way, the words combining an ancient 'root' meaning modified by prefixes and suffixes. What we find is that a particular modifier adds the same expansion of the root meaning each time.

[8] Apple symbolism – Wikipedia https://en.wikipedia.org/wiki/Apple_(symbolism)

Take simple words ending with "-or," for example. That suffix adds the natural design meaning "doer" to each one, as in the words "activator," "actor," "projector," or "progenitor." The root words alone refer to some condition, but the suffix then associates the root state with the source of its causation, to mean a lot more. The combination gives the new word strong "emergent properties," as with most compound words.

Fig 15 shows how the meaning of the word "community" is assembled from its syllables, combining "comm-" meaning '*together,'* and "unity*"* meaning '*one*,' referring to things brought together as one. It is the emergent meaning from combining names for 1) the quality and 2) the instrumental process to form that captures the transformative meaning of the important natural design. To confirm that would take explore other examples to see how that way of enlarging the meaning of word roots operates. From there the next step would be to study the overall pattern of natural relationships as a nameable design and identify the implied "forces" and the "unifying organization" that presents them as a nameable ideal.

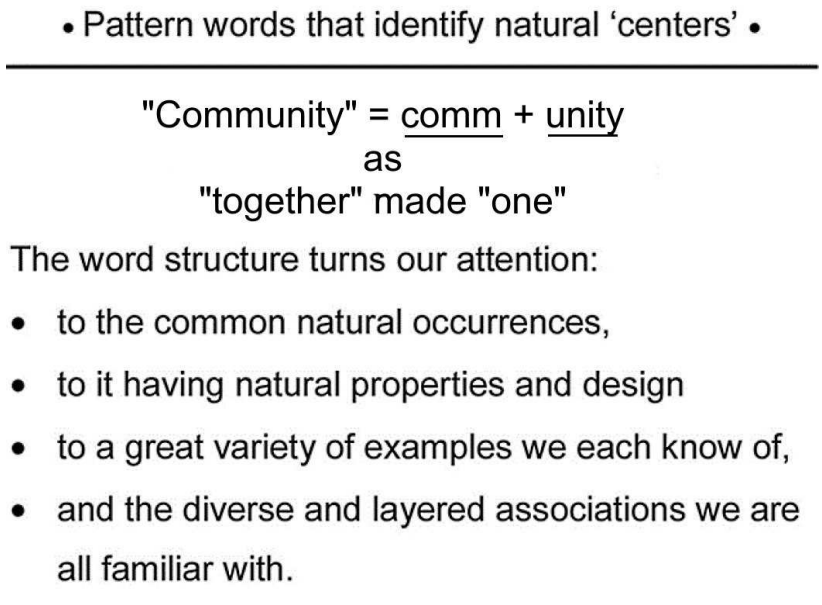


Fig 15. Words built to name natural patterns of design

To better understand how modifiers amplify root meanings with their roles in nature, it helps to look at whole lists of similarly modified root meanings. In Table 4, below, for example, are a very few of the over 2,000 common words in English that have the suffix *"-tion."* It helps to study the whole list of terms with that suffix to appreciate the kind of new meaning the suffix consistently associates

with the root[9]. That then helps one turn one's attention back and forth between the meaning of the word root[10] and how the modifier,[11] transforms its meaning, in this case, to create names of common transformative processes and the associated ends states that result.

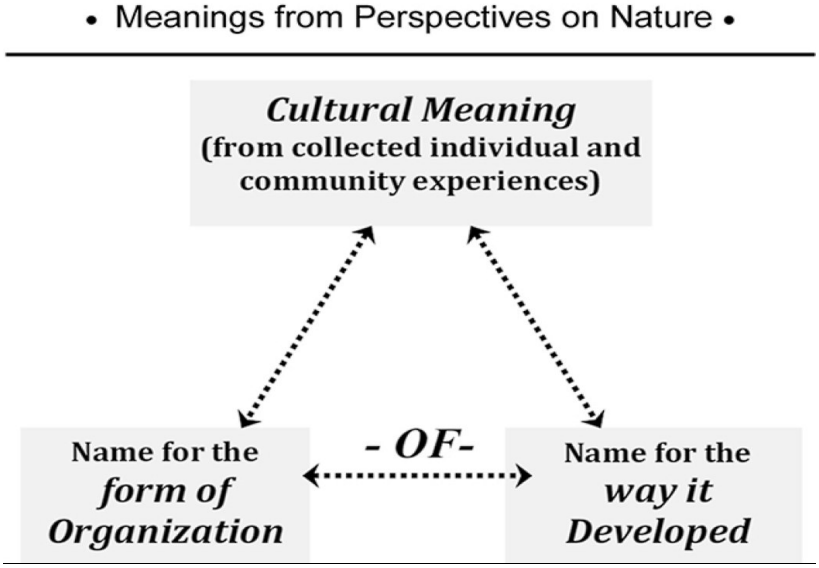


Fig 16. Three dimensions of grounded meaning

[9] OneLook dictionary search for words ending in "tion": http://www. onelook. com/?w=*tion&scwo=1&sswo=1

[10] 'root' http://www. thefreedictionary. com/root "The element that carries the main component of meaning in a word and provides the basis from which a word is derived by adding affixes or inflectional endings or by phonetic change."

[11] 'modifier' http://www. orbilat. com/General_References/Linguistic_Terms. html "a word or phrase that makes specific the meaning of another word or phrase."

Table 4. Root, Transformations & End State Meanings

Expanding root word meanings with the suffix "*-tion*"		
Root + Suffix	Transformation	The Result
• *comm ◦ uni ◦ cation:*	The process	What was made one
• *co ◦ oper ◦ ation:*	The practice	What was achieved
• *vocal ◦ iz ◦ ation:*	The expressing	What was expressed
• *abbrev ◦ iation*:	The shortening	The short form
• *dele ◦ tion:*	The removing	What was removed

What these richly meaningful terms of English have in common is this simple way of being elevated in meaning. It is a linguistic invention that came to English from the Latin of early Rome[12] The added meaning the device produces has one more twist. What seems very curious and important is that these "*-tion*" suffix words are used to name both how a transformation takes place and the end state it results in, a key double-reference to both temporal and spatial dimensions of the reference subject. I was shocked when I first found that. The third part of the meaning is the association of those natural designs with all our accumulated cultural experiences of them. It is like a whole textbook of complexly related meanings in every word! (Fig 16).

For each word in Table 4, the compound word refers to both the end state and how it came about. "A*bbreviation*" refers to both the shortened form as well as the way it was shortened, along with all our cultural associations with both. To understand any state of being you'd surely want to know all three, but who would have guessed that combining 1) our recognition of important natural patterns, 2) our understanding of how they developed and 3) our cultural experience of them, would be all combined in the meaning of our words for them?

[12] - tion: suffix of Latin origin, to form abstract nouns from verbs or stems, to express actions, states or associated meanings - http://dictionary. reference. com/browse/tion

This deconstruction of compound word meanings is a reliable device for expanding on the word meanings, either to enrich the reading or for research. In either case, it is likely to deepen one's appreciation of the many living qualities that common language gives us access to and to give you more ready access to them where it matters.

3.4.3 Individuality as a Repository of Unique Designs

Individuality is a puzzling phenomenon. In a world we think of as following fixed rules, individuality seems to be evidence of nature creating everything individually, producing unique designs that cannot be duplicated, and so to never be seen again. Examples include living species and cultures, the singular achievements of great artists, actors, scientists, and politicians, individual storms and lightning strikes, snowflakes, among many others. Individuality can also be seen in singularly simple new forms of design, like the wheel or hairpin, which have outsized influence, adding a new dimension to life.

Truly individual things, naturally, come about unexpectedly, as the individuality of people comes out unexpectedly. They are not so much exemplars or ideals of some category, but "true originals," with a form and new category all their own. It makes "individuality" another mysterious property like "wholeness," but for identifying things of the extraordinary unrepeatable kind, good and bad, rare or familiar. Of course, a problem with categorizing individuality that way is that, technically, nothing in nature is repeatable, particularly for complex design. As they say, you can never step into the same river twice. Still, 'individual' and 'individuality' are very commonly used words and easily spoken of as having varying degrees, as an essential property of the thing itself, rather that needs to be determined by an observer. It is a puzzling phenomenon, indeed.

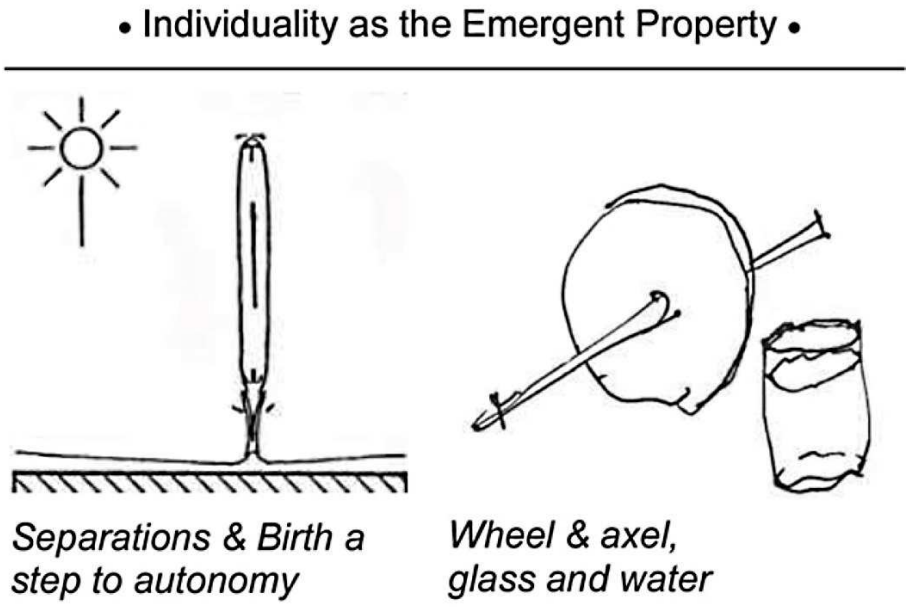


Fig 17. Emergent individuality & abrupt change of state

Evidently, our having valued ancient words for it indicates they refer to something of value to us that we recognize and consider from many points of view. But it is still not really clear we can really study the individuality of things. What our minds are better suited for is studying the common patterns of things that we can put in a category. So it appears individuality may be something special, expressing the limits of our perception as the aspect of designs that we admire but find beyond our understanding. So it may refer to the quality of natural designs that are so very original we find it hard to see them as having patterns, a matter of perception.

Not knowing quite how to categorize individuality, I've just chosen some examples of "rapid" and "slow" emerging individuality. Fig 17 shows three images of rapidly emerging individuality. Individual air currents are represented here as a small rapidly emerging vortex ring energized by hot air adjacent to the surface below, as a way to tunnel through cool air above, and stretching out till it separates from its source of hot air below. Gusts of wind and storm cells are similar transformations at much larger scale, complex systems that solve the common problem of how to relieve pressure when the whole atmosphere is in the way.

Combining a wheel with an axel, and water with a glass, depict profoundly transformative designs. They both have been reinvented in new forms, again and

again, the wheel probably starting as a rolling log, and the glass as a gourd perhaps. Their designs, though, seem to take place abruptly and change the whole meaning of life in the future. The funny thing is that these simple transformative combinations that perform something quite new and life-changing are not at all rare. Almost anything people use is made to join complementary opposite parts to benefit from the emergent properties when combined. It is what nature and people both do. These three are just classic examples.

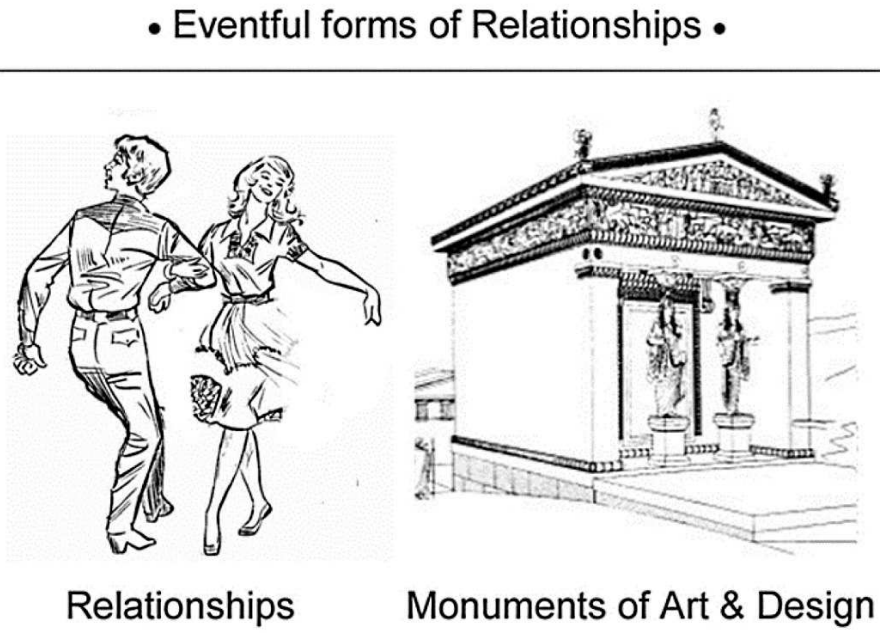


Fig 18. Emergent individuality with long development

Individuality is also seen in the variety of new forms with emergent properties that take extended periods to develop. That is the deeper story I notice behind the life of a happy couple, for example. It is more than great moments but relies more on the long continuities. Another case is the advent of Greek architecture as a monument to the long history before (Fig 18). In both cases it would have been hard for anyone to predict where the long development was headed until it got there. These are just special examples of how great designs commonly involve a long series of development, for both intentional and naturally occurring designs. Of course, if what we notice is the just the completion and climax of the emergence process (Fig 3 & 4) the late recognition of individuality emerging may be the normal case.

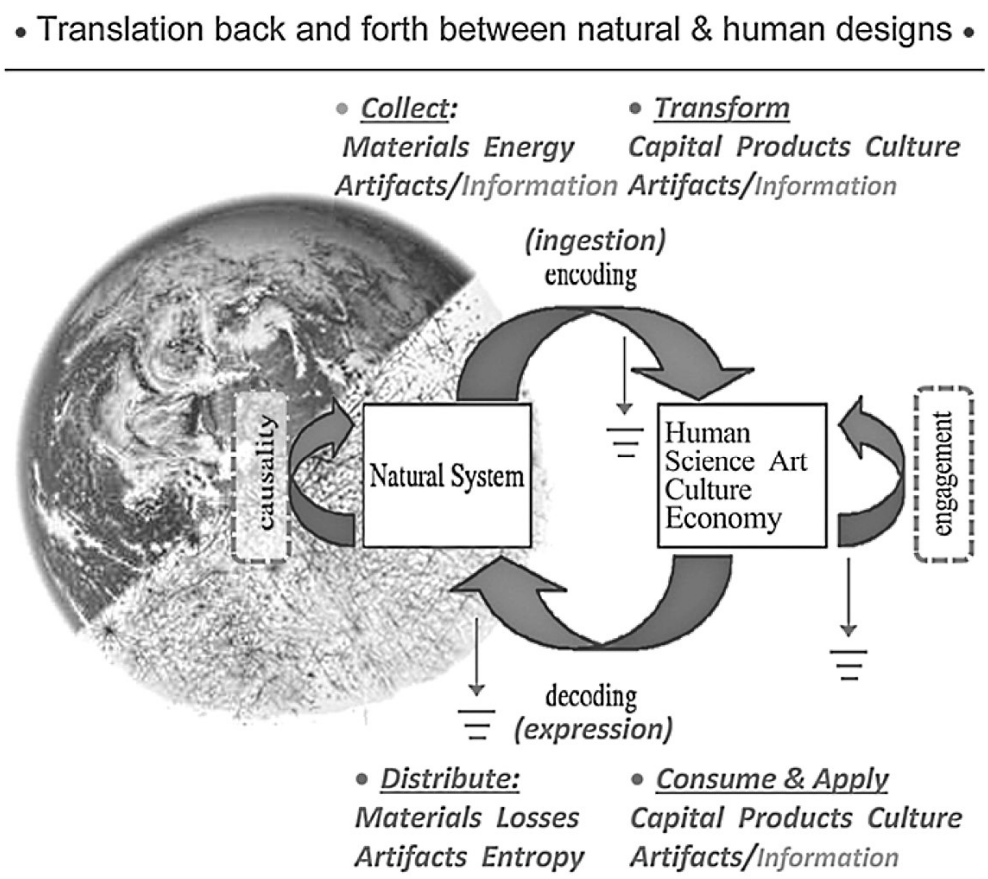


Fig 19. All our cultures learning together separately

Part of why individuality appears to occur suddenly, even when it has taken a long time, is same reason a car or a meal is unrecognizable until the end. The design as a whole does not come together till the end. So an observer may see something going on, but to see the completed pattern our minds may have to wait, for the time when its climax state may be realized suddenly. For example, though nothing changes when we graduate from school or achieve professional recognition, the meaning of all those years of slow development that went before can suddenly become apparent.

We also see individuality that puzzles us in humanity's way of living on earth, the technology take-off and endless expansion period of growth going well beyond our conquering the earth. With no other objective, growth at any cost both becomes costly and also loses meaning. Like any organic growth process in nature, perhaps our economic growth will lead to some new form of life. In this case, it is as an experiment partly of our design and now confronting us with a need to give it some higher purpose. That would be a learning process, of

engaging our conceptual thinking with nature's systemic world (Fig 19), shown here as a variation on the Robert Rosen's model of science as a cycle of encoding and decoding nature (Fig 1). The challenge is to find in a new way of living on earth, as our pure pursuit of wealth loses meaning.

The real point is how hard it naturally is to recognize individuality when it is still immature. We might very well not recognize ourselves until after we find out where we're going on our journey, so good to aim high! The picture only shows a general diagram of the process. It does not show whether the "chicken and egg" cycle of growth is on the way to becoming a fulfilling one or not. Today, we are in a difficult struggle to secure the earth as our good home, not yet aware of who we are to become. We will find whatever we find, by turning our attention back and forth between our work and mulling it over, in the usual way alternating between interpreting and acting on our world. Hopefully learning to appreciate both what is found and lost in translation will show us the way.

3.4.4 Alexander's 15 Principles of Wholeness

Table 5 shows varied illustrations of Alexander's 15 identified features of "wholeness" (2002). They are very common features of natural design as well. The intent is to present varied perspectives expressing richness of possible interpretation. They help suggest where these or other rudimentary features are found and what they do. I've included some of my illustrations and with those of two others, along with a few questions and suggestions.

Appreciating any complex subject takes looking at it from multiple viewpoints. So just as the fabled "six blind men" describing an elephant are handicapped by not looking for commonalities that would let them communicate, they are also handicapped by failing to "look around" for what else might be connected to their initial impressions. Looking at different views of the same thing, 1) helps expose unexpected connections, and 2) helps keep one's thinking fresh and avoid becoming stuck on any one view.

Alexander initially developed his 15 principles from an unusual pattern repository, a study of the timeless beauty of ancient Turkish carpets (1995). An interesting view of it from a carpet trader's view is found in Detlev Fischer's sort online article (2010). I see Alexander's 15 features of wholeness as a very useful collection of shape patterns found in whole natural systems, though not inclusive.

They're all 'spatial' patterns, and a similarly diverse collection of 'temporal' patterns, like the "phases of growth," or ecological processes of allowed by "mediums of exchange" might be collected along with other design and pattern primitives too.

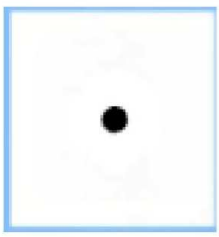
I find primitive patterns like these most useful when used for "pattern-search," to help understand how a context is organized (Fig 5, 8 & 9) helping one trace the working parts of natural designs and their connections that design patterns serve. You could think of them somewhat abstractly as for pattern 'stigmergy,' interpreting the environment as a lacework of often traceable trails to follow. So one can use the 15 principles and their variations for either helping to explain things where you find these patterns, or just to help explore what is living.

For example, Pattern 01 here, "Strong Center", is shown with three images of 'centers,' a point, a cathedral plan, and a discussion circle under a tree. Those are different kinds of "strong centers" that never the less have a lot in common. Many others could be added. But you need to think of the variety to begin to understand both the common principles involved, and to become free with discovering and using their varying use in other circumstances.

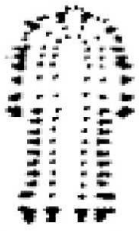
Table 5. Images of Alexander's 15 characters of wholeness

Illustrated by Leitner (2013), Reckard (2011) with related images and suggested occurrences in naturally occurring design by the author (Henshaw 2015d)

[01] Strong Center



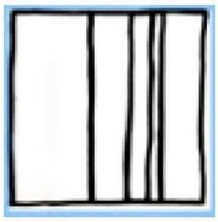
Centers

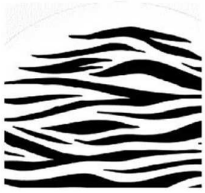


Cultures & Commons

Hives of Activity,

[02] Level of Scales

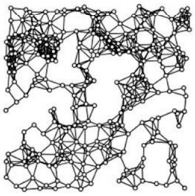




Waves & swells

Successions of form

Density, organization & proportion



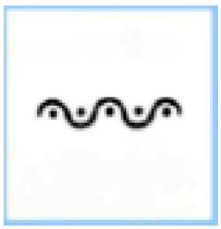
Scaling patterns of

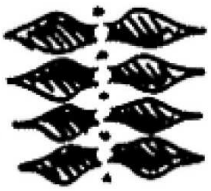
Distributions

[03] Boundaries, Geometry, Walls, Transitions, Limits

- paths of growt as natural bounds
- ranges of behavior as natural bounds
- Margins of ecologies -, trophic scales, neighborhoodscircles of relations
- Limits of Visibility, - of Reach, of Scale, of Change, of Versatility

[04] Alternating, Repetition, Recurrence,





- Vitality, Resilience, Responsiveness
- Cycles and waves of change
- Practice & training, perfecting
- Looking back and forth, inside and out, foreward and back, poking around
- Successive addition or subtraction, of layers of design, or branching from designs
- Hysterisis, Action learning, Exploration
- Semi-lattice (as added complexity with added variety of opportunity)
- Stigmergy (trail reinforcement)

[05] Positive Space, complementarity

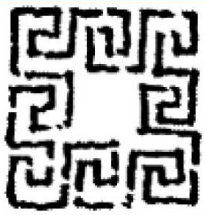
Openings Permeability

- Open environments
- Spaces of free association and adaptation
- Proximity with separation
- "In-betweens" and freedoms of movement.

[06] Good Shape & form

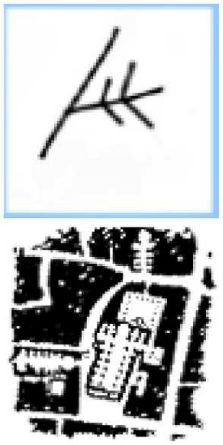
- Simplicity of design
- Comfortable and Complementary fit
- Serves intersecting needs
- Serves exclusive needs

[07] Local Symmetries



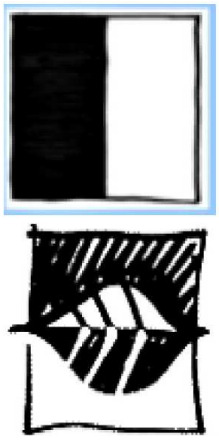
- The impossibly complex overlap of so many things working independently
- How nature can only organize separate things and our reason can only organize mutually defining things, looking for one world in a life of so very many worlds

[08] Deep Interlock and Ambiguity



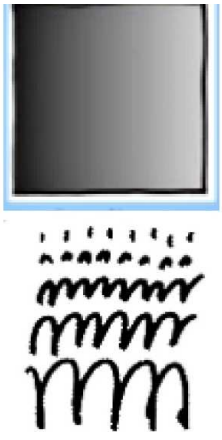
- Polarities: roots and branches
- Approaches and arrivals
- Interiors and exteriors

[09] Contrast, difference



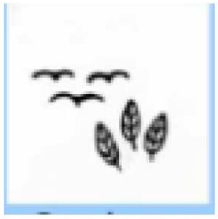
- A bridge between information and matter
- Revealing things hidden from view
- The potentials for complementary fit
- Signs of transition

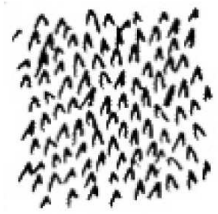
[10] Gradients



- Energy gradients to power orgaization
- Proximities, potentials, distance, values
- Margins, ranges, cushions, resilience, flexibility, continuity, versatility

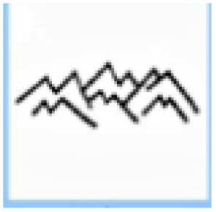
[11] Roughness, diversity





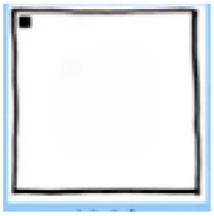
- Inconsistency, consistencey, texture,
- Intermittance, irregularity, courseness
- Surface, ground, skin,
- Fabric, aggregation, collection, granularity

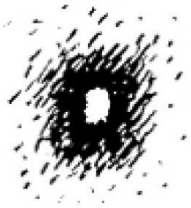
[12] Echoes



- Spreading and lingering reflections; elastic vibrations; memories of lost places, events; artifacts of periods of change
- Environments as repositories of fragments and footprints, a compost of discards,
- Traces of history as memory of all past learning and change, ornamenting things new

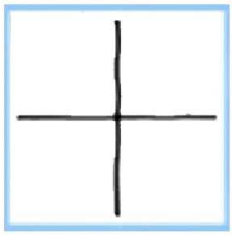
[13] The Void

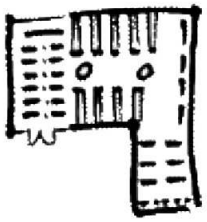




- A lack of form, absence,
- ‘Book zero’, the potential of formlessness,
- The uncertain silence, the moments of stillness, pauses, suspense, immobility

[14] Simplicity

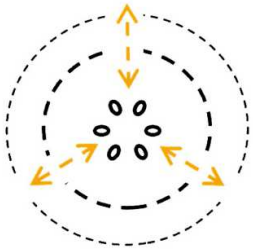




- Inner Calm
- Freedom of direction
- Balance
- Observing, listening, receptiveness
- Emergent couplings, organization
- Individuality

[15] not-separateness, Living Quality, "QWAN"

connectedness, mutuality



Homes *Flows*

- Homes, their receptive places and animating cultures
- Organization as a pairing of receptive places and active users, the material differerence between parts and whole,

Discussion

I hope I have presented an interesting introduction to the rich field of naturally occurring patterns of design, that readers can enjoy and use to explore natural patterns of design and further their work. The qualities and real meanings of both purposeful and naturally occurring designs seem to rest on the functional organization that contributes to emergent properties of the whole. I'm certainly very grateful for having found how Alexander's pattern-language has evolved, opening this door to talk in more detail about the patterns of dynamic organization I found too. As a general method for communicating sound principles of holistic design, pattern language seems to give me a way to translate years of prior work to make it communicable. It lets me separate the discussion of purposeful designs

and naturally occurring designs. It lets me serve them both equally and by being separated then better show how they can be understood as usefully connected. It adds “new forces” to my world that allow the cooperation of previously disparate ones.

That serendipity gave me the freedom to discuss the details of two of my favorite natural patterns, the Two Primary Patterns discussed in Section 2, ‘homes’ as the strong centers of whole natural world, and stages of growth as its process of self-organization and means of energy use, characterizing both purposeful and naturally occurring design. I hope that brief look at these two key patterns was adequate, for then offering the “Starter Kit” for the method offered in Section 3. That “kit” composed of a few dozen variously simple and advanced ways for readers to branch out with their thinking, presents a collection of naturally occurring designs to explore that have fascinated me tremendously. I’d like for others to find as well their recognitions of the bridges between our purposeful designs and naturally occurring ones such as the one I presented that opened the door to everything else I found.

I’ve mostly referred to natural patterns of design as something we might study, but without discussing much of how they appear to work by themselves. I’ve also been critical of mainstream science, for representing nature with equations that omit many of nature’s more prominent features. So below I offer remarks on those two subjects, first on how autonomous natural design processes really “do it,” and then pointing to where I think science may be heading in the near future.

3.5 Natural Patterns of Learning

If you consider how new art forms develop, say “impressionism” as a style of fine art painting, or “Hip Hop” as a popular culture and style of rap music, it is clear they originated with a series of bursts of innovation, but also had deep roots and a long underground history, making where it really came from mysterious. You do notice that continuity in passing on the patterns of design it began with, though, elaborated on it again and again while remaining faithful to its original genius. That is also true of many other kinds of individual whole-systems, even seen in snowflakes that show elaboration on the central design as new crystals and branches are added on. Our lives are mostly like that too, extending patterns

from how we were formed as individuals, keeping the core while adding on distinctive branches.

That seems to be a common pattern in anything that develops by growth, forming complex systems that work as wholes. Natural designs of that kind seem to remain "true to their roots" that way, as if only able to extend the pattern they began with. It seems to be virtually universal, for any new design to develop by itself to need to have an original design for adding new parts that extends the same pattern for adding more parts. It needs to have a "pattern of replication," making copies, as an essential function for designs that will "emerge," adding layers in a way that makes new places for more layers. Beyond that is seems the variety of natural patterns that replicate is exceedingly varied, perhaps as numerous as snowflakes, but also as uniquely individual.

It appears to mean that the small beginnings of things set a pattern that only attaches that extend the pattern as if in the manner of a snowflake starting a pattern of crystallization that catalyzes more of the same pattern of crystallization. In a general way, that also appears to be the natural form observable in adaptive replication. It is also a fairly apt depiction of what people spend their days doing too, looking around for the next thing to extend their pattern.

• Design starting from an origin pattern •

Fig 20. Snowflake design developing from the center

It might set a somewhat new, but as a pattern for extending a pattern, it cannot be so different to break the replication. So for the evolutions of designs by growth, that we observe as accumulating creatively rather than deterministically such as what we see is resulting from growth, the original pattern needs to be replicated in an exceptionally faithful way, just to continue to do so for a great many replications.

So that process of extended replication also seems to be a necessity for something small to get big, and so to seem universal. What a replication of parts also allows is a multiplication of faithfully replicated parts, another feature of the general pattern for how small things get big that seems universal. If faithful replication were to be linear in how it progressed, a single fertilized cell in the womb adding another cell every week, it would take 19 billion years to reach birth weight with about a trillion cells! With every cell made doubling every week, it only takes nine months. So it seems real complexity would not be remotely possible without it.

You can see these patterns of growth directly in the shape of a snowflake (Fig 20). The new layers do not exactly replicate the first ones but add onto them while providing new locations that get added to, and so elaborate on, or branch from, the original. How the whole becomes so distinctive is by some crystal edges being more receptive than others for new crystal formation as “hot zones” for catalyzing new crystal formation. The form of the whole is then being determined by whatever parts replicate their crystal pattern the fastest.

The interior parts of the snowflake are highly symmetrical and repetitive, but outer branches become fairly irregular, so it seems the replication pattern deteriorates somehow. So, it appears the evolution of complexly organized designs is a matter of finding a very successful design for continually having an answer to the question “What is next?” but more of an open question than one answered by laws.

Much that same general kind of growth pattern can be seen in the course of the world economy (Fig 21). The way it builds on itself is by using the profits of businesses to add to the scale and kinds of businesses that make profits, the chain pattern of reliable replication that readily multiplies. That expands the system by making more options for expanding the system. The big difference, of course, is that it is a highly complex cultural/*technological system*, guided by decisions

based on information about monetary profits. That is a big difference, but other than the very different design for replication they start with, the two are similar in having to be faithful to their start and having no design for ceasing their replication.

• Design starting from an origin pattern •

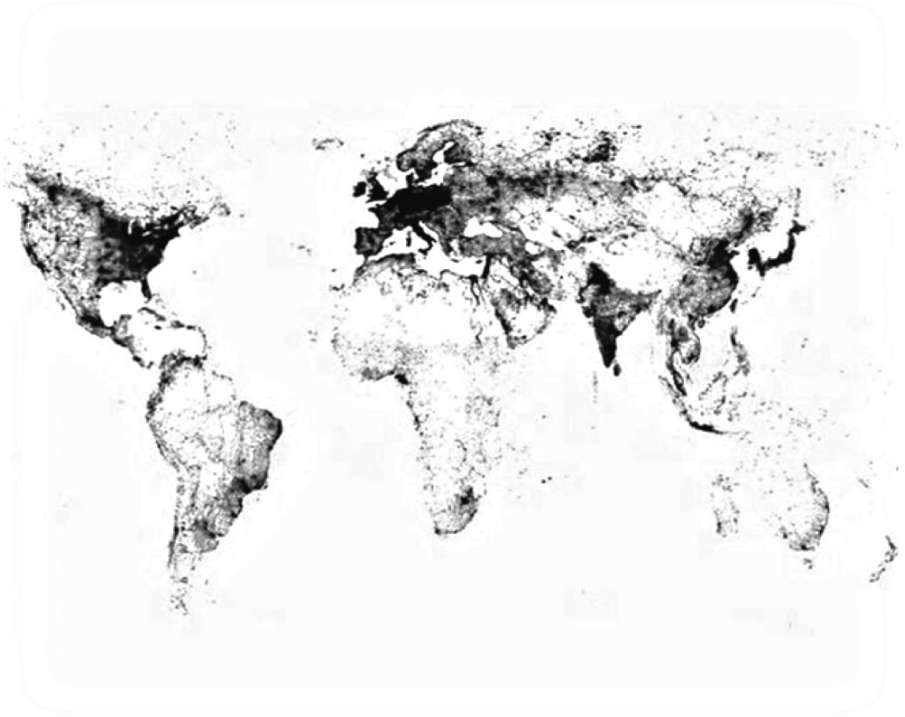


Fig 21. World economy growing from all cells at once

The snowflake keeps attracting more layers of crystalizing water vapor as it falls until the water vapor runs out or it meets warmer temperature at lower elevations. What would make the replication the world economy's parts stop before exhausting its resources or making economic environment unprofitable? You'd think the latter cause, general decline in profits as we are starting to see now would only stop growth if profits declined toward zero, and investors withdrew their assets from risk. It is the logical endpoint of a growth system that grows without a goal, a "pattern problem," and an "imbalance of forces."

It is one that would ideally call for some "unifying design" to resolve it holistically, rather than simply letting it run its course. To attempt that you'd first spend a lot of time looking for patterns that embody the same circumstance, to

find working examples other transformations that are possible, and their "simplifying ideals" for resolving the forces. Nature does indeed seem to display all kinds of creative ways of furiously replicating patterns that then smoothly resolve the imbalances that come naturally from it.

Whether it is a snowflake or a world economy, this way of recognizing patterns of natural design offers a way to identify and find ways of studying their complex design, and with 'pattern-search' as a method, identifying their recurrent design patterns. Use of it could then result in a greater understanding of both of our real subjects and the deep common roots of human understanding. Most importantly, it seems to allow individual forms of both intentional and natural design to be recognized as objects of organization, each an individual with its own developmental origin. We can also identify and verify many of their stages of development, and consider them from many perspectives. It changes our perception of all these emergent forms, raising their status as objects of nature, letting them be much better understood and increasingly relevant as tangible realities for us to work with. We might still find them mysterious, certainly, while we become more able to confirm them as individually occurring forms, possible to study, mutually observed, and opening new subjects of discussion well-grounded in nature.

3.6 An "Object-Oriented Science"

In the introduction and elsewhere I've long been fairly critical of mainstream science, for limiting its study of natural design to the invented equations we based on the categories of data we collected. That approach completely overlooks the dense centers of organization exhibited by individual energy-using systems. Those include all the kinds of living organisms as well as living cultures, as well as any number of other kinds of complex energy-using systems that develop their organization by growth, giving them organizational independence while leaving how they work hidden from view.

It is those classes of "objects" that I see the sciences as needing to find how to study. So here I'd like to briefly describe what I see as a way for mainstream science to recognize and start to explore this new territory, without abandoning the mathematical tools it uses. The sciences have mostly restricted themselves to looking at the rich multi-dimensional designs of nature through a lens of one-

dimensional measure, “data.” Now science can potentially begin to also refer to the whole objects of nature, in their forms, just by recognizing where they are by their locations. One can then study their uses of energy, for one thing, using the same “black box” methods as for machines. It will not reveal everything inside the box of course, but using a “green box” instead would at least lead you to recognize more natural forms. The “green box” would still define the location of the subject being studied. So in those ways, this approach is just an incremental change in methods of boundary definition, for recognizing the boundaries of “whole systems” (Henshaw 2011)

With learning to recognize boundaries of independent cultures, the potential is then clearly there to greatly expand the subjects that the sciences can define and study, that were never studied before. The individual systems then possible to study are found throughout nature on every scale, and if recognized as having boundaries could be named and studied as individually organized wholes. These objects of nature that do appear to work as wholes would then be recognizable as the units of design that life works with expands the potential view of science further.

The expansion of subjects could also come directly from current conventional research methods in the mainstream sciences. It might be from scientists seeing a need for a better way of “taking notes,” in following the hotly pursued search in complexity science for way to understand the emergence of new properties and forms. Feynman had a wonderful notation system that helped speed the advance of physics, for example (Moody 2009). It might be a notation, just to help with keeping track of shifts in organization observed while studying the uncontrolled behaviors of complex AI systems that spread to other uses, perhaps. It might also come from some taxonomy method used in forensic science, maybe later borrowing concepts from Alexander’s pattern-language, or not. All the methods that worked would get their validity from being means of learning from the same natural forms, and so be interconnected and interrelated by that.

Given the demonstrated potential power of a pattern-language view, the emerging new views of nature in the complexity sciences and those of pattern-language will eventually approach each other and meet in the middle. Each is likely to retain its individuality, and while using differing technique also learn

from each other's perspective, producing a greater view than either when combined.

One can also imagine barriers to doing that arising, like cultural and institutional silos invested in old ways and resistance to change. Perhaps each science would insist on sticking only with its own somewhat proprietary way of describing a different world. That would have each continuing to wandering off in its own direction more or less continuing the historical pattern of separations. They might still study their very bodies of information as if different "realities," that as for the "six blind men" and the elephant, seeing realities that do not connect. To upset an entrenched habit, you might need some unexpected event, like the coming realization we have the wrong economy for our society to survive on earth. It might go along with a very useful new way of recognizing the individuality of natural systems and their development, connected to a way to make the ancient principles of holistic design explicit. That new generation might look up from its boredom and "blink," to then takeoff on the task of connecting the new with the old and expand our whole way scientific thinking.

There are various names one might consider for the contribution presented here. Often new forms are named by happenstance, often by the group that first makes them useful. As a working name, I use "object-oriented science." It is neutral, directly descriptive, and already used as an expression with closely related meaning. One can probably trust that interest in the qualities of "aliveness," "living quality," "individuality" and "wholeness" found in both the most appreciated kinds of intentional and natural forms of design, will carry over. Helmut Leitner and Franz Nahrada propose the more direct "liveliness science" as "lebendigkeit science" (2014), a nice way of saying it. I called my research archive on the subject "the physics of happening," so I have affection for that. The first question I had that became productive for my studies was: "What makes life lively?" We could call the science "liveliness" then, or perhaps just "individuality" or "nature." With one of those terms, non-scientists might more quickly get the whole idea that the name refers to the real subject of study.

If we want it to spread, though, it needs to stay faithful to its roots while continuing to be clarified, expanded on, and made more relevant to users. It also needs to become more adaptable to new domains, shareable across disciplines, maintained as a broad common language, and to expand to new areas and

disciplines, like this effort to introduce a direct way to learn from naturally occurring design.

JLH

Elements - Figure and Tables Lists

Figures

Tables

Acknowledgments

I have many people and fortunate circumstances to acknowledge. It was the clear way that Christopher Alexander's pattern-language became discussed in the software community that first made it clear to me that I could use it too, which I greatly appreciate. It allowed me to translate the patterns of natural systems I found and wrote about in the 70's, when Alexander was doing his seminal work into this more communicable way of discussing them. I had a fine education in physics too, at a small college with a wonderful physics department, professors Peckham and Rohmer at St. Lawrence Univ. They encouraged my odd studies of how lab experiments always misbehaved. I found inspiration at the Univ. of Pennsylvania School of Design too, both from visionary faculty and the pervading presence of Lou Kahn's deep ways of thinking about the natural form. Of course, I am also indebted to being taught how to observe natural patterns from a very early age by my father Clement L. Henshaw, a professor of physics at Colgate. His idea of teaching was to show students where to find explanatory principles for themselves. I also owe thanks to a friend from high school, John A. Blackmore, who became a social scientist and I must credit with many of my key insights, as well as being a constant intellectual partner with a wonderful appetite for any subject we could think of talking about, through all the years.

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Jessie Henshaw

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