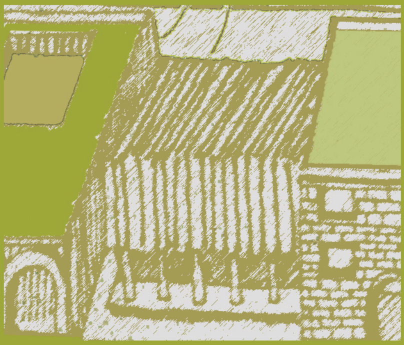

Sustainable Buildings

From Pattern Languages To Generative Codes: A Report On The Work Of Christopher Alexander And Colleagues & Its Application To The Regeneration Of Traditional Settlements

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INTRODUCTION

Indian citizens, like American citizens, are all well aware– perhaps sometimes painfully aware– that their country is growing at a remarkably rapid rate today. This growth is economic, and of course also physical: new structures are being built, and in many cases old structures are being destroyed to make way for them. Sometimes natural structures are being destroyed too: wetland vegetation, riparian ecosystems and the like. Some aspects of this growth are clearly very positive, offering benefits of sanitation, education, quality of life, and new opportunities for people who have lacked them for too long. Some aspects are less positive, and are even worrisome contributors to unhealthy processes that may soon become catastrophic – climate change, resource depletion and other grave threats to the welfare of the human species.

We talk about growth as if it were one undifferentiated thing, but we are learning today that this is not at all the case. In the natural world, there are highly variable forms of sustainable growth, which create dynamic equilibrium; and there are also variable forms of runaway growth that cause decay or collapse– for example, metastatic cancer, or runaway infections, or the collapse of underlying resources.

Christopher Alexander, a Cambridge-educated mathematician and physicist who became an architect and builder, has spent some four decades thinking about this question of the nature of growth, our understanding of it from a scientific point of view, and our ability to shape it in more desirable and more humane ways. From the beginning of his career Alexander has been preoccupied with the problem of morphogenesis: how forms are created, how parts create wholes, and how this happens in nature and also in human constructions. Importantly, he has sought to understand the difference between the two, and the lessons this may offer us for our current challenges.

At heart Alexander asks: how can we develop a healthier kind of growth– the kind that repairs and heals and improves, that makes places qualitatively better, instead of worse? How can we preserve and build upon the gifts of the centuries handed down by tradition– not as dead relics, but as a living force that infuses our own time with a greater vitality and robustness?

Alexander is not an anti-modernist, but rather a modernist reformer. He wants to know, how can we find a more intelligent kind of technology, more adaptive, more integrative of the wisdom gained over centuries, more enduring and sustainable? What are the "rules of the game," so to speak, and how do we change those rules to create a more intelligent and wiser human future? Apparently quite a lot is riding on these questions.

This essay will report on reasons to be hopeful about the answers, particularly those beginning to emerge from the "new sciences" of complexity. It seems many of the answers are indeed to be found in nature, including human nature. Some surprisingly modern lessons are to be found in the rich "collective intelligence" of human traditions, of the very sort that we are presently discussing.

THE CHANGING SCIENCE OF URBANISM

Over four decades ago, the urban and economic scholar Jane Jacobs famously described the profound revolution then under way in the sciences of complexity, and its intriguing implications for the structure of settlements. In the marvellously prescient final chapter of her 1961 book, *The Death and Life of Great American Cities*, she argued that the then-emerging new science of "organized complexity" was beginning to revolutionize our understanding of what she called "the kind of problem a city is", and our methods of managing and planning urban environments.

Much has happened since that time to deepen our understanding of the processes of organized complexity: the phenomena of morphogenesis and genetic coding in biology; the behaviour of cellular automata, individual elements following simple local rules to produce emergent global complexity; and the self-organizing processes of markets and human cultural activities, which have produced, for example, the rich complexities of traditional settlements through history.

In this story the work of Christopher Alexander, by all accounts, plays a highly influential role. Here I will briefly describe his work up to the present day, and the most recent stage in its fruitful evolution. It is heavy on theoretical insights, but rooted in the realities of construction and culture, and in particular traditional culture. In fact it is not a coincidence that Alexander's first project, as a student, was a village in India, and I can convey his keen interest in collaborating on the challenges presently under discussion at the INTBAU India conference. It would be a nice resonance indeed if his career brought him full-circle to such a beautiful part of the world, facing its own set of challenges with growth and tradition.

Alexander has always been concerned above all with the process of creating form, and the way that qualitative characteristics emerge from such a process. He was part of a group of cybernetic theorists in the late 1950's and early 1960's that included Herbert Simon, author of "the Architecture of Complexity," and George A. Miller, originator of the influential concept of "chunks" in information theory. The overriding challenge at that time was to understand the essential structure of information, and its relation to the corresponding reality that the information is intended to model, in what is presumably an accurate and useful way.

It is fair to say that Alexander's first book in 1964, "Notes on the Synthesis of Form," had a profound effect upon the next generation, not only in planning but also in cybernetics, information theory and other fields. And although he has since moved far beyond many of its precepts and even disowned some of them, the foundations of all of his later work up to the present day were laid here.

Like Simon and others, Alexander argued that things go together, roughly speaking, in hierarchies – like the fingers on a hand, or the limbs of the body. But the "roughly speaking" is the interesting part. For in fact the hierarchies tend to overlap, and interesting and important things happen in those overlaps, and those networked inter-connections.

But the problem, as his classic 1965 paper "A City is Not A Tree" showed, is that humans tend to think in hierarchies, and tend to design in hierarchies – with results that can be disastrous for a natural structure like a city. The enforced hierarchical order tends to limit and to sever the essential interconnectivities of the structure, and to destroy the complexity and the life of it.

This was not so much an empirical argument, as Jacobs and other critics of the master-planned cities then in fashion employed to good effect. It was rather an elegant and devastating mathematical and geometric analysis, which put the discussion on a refreshingly discussable, sharable scientific basis. It established a simple structural dimension to the problem.

THE EVOLUTION OF PATTERN LANGUAGES

For Alexander, the obvious challenge that remained was, what methods can we use to overcome this problem? How do we develop tools to successfully manage these overlapping, interactive, web-like structures? That was the basis of the next major piece of work – the development of pattern languages, and the particular library of 253 environmental patterns included in the 1977 book, *A Pattern Language*.

Patterns in this sense may be thought of as recombinable fragments of geometric configurations, which obey a kind of grammar much as a natural language does. Just as a natural language uses a fairly limited set of elements to be recombined into endless possible configurations, so a pattern language is intended to be recombined in a much more flexible, networked kind of way. In this way, the mistakes of an earlier and more rigidly hierarchical approach could be corrected.

Alexander offered, in effect, a method by which designers could overcome the limitations of hierarchical thinking, by inter-relating elements of the human environment into an adaptive network. And he noted that traditional cultures have been doing something much like this already for millennia, and that this traditional practice does in fact function as a sophisticated and powerful kind of language for creating the built environment.

More than that, it is an expression of the actual structure of things, the way things go together in space. Just as a natural language can describe the endless ways that things can in reality go together, and thereby serve as a useful tool to discover and plan new combinations, so a pattern language can model and guide the assembly of elements of the built environment into new networked configurations. In that sense, such a language is useful because it is open-ended, in just the way that life itself is open-ended.

The new pattern language proved itself immensely useful in other fields, including software programming – which itself functions as a kind of language. The breakthrough spawned a new class of object-oriented software, design patterns, leading to familiar innovations like The Sims and Wikipedia, and many other less familiar innovations.

The book *A Pattern Language* had of course an enormous influence on architecture and planning as well, and in fact is said to be the best-selling treatise of architecture in history; a quarter-century later, it is still a perennial strong seller. It was a major influence on the US New Urbanism movement and related movements elsewhere.

But for Alexander that wasn't enough; merely having the letters clustered into some beautiful words was hardly sufficient to show you how they should go together into sentences and essays and poems– how, in the case of architecture, one could get to the formation of coherent and beautiful structures. It is one thing to put nice words together in rudimentary form, like an elementary reader. It is quite another thing to produce Shakespeare. In effect this was the enormous qualitative gap that Alexander sought to close– or to take the first important steps toward closing.

EXPLOITING THE PROCESS OF MORPHOGENESIS

Hence Alexander believed his work had to deal more directly with the problem of process. What is the process by which this language is actually used effectively to create form? What are the steps one must go through? Whereas pattern languages were about the structure of things, offering a kind of library of recombinable fragments of that structure, perhaps this new work would be about the process of creating that structure. The library this time might be of recombinable fragments of steps, rather like the steps in a recipe, that tell you how to get from one stage of form to the next.

Alexander's insight came again from traditional cultures, as it so often did. He observed that building traditions guided individuals in specific steps of building, and in how those steps should respond to their context. Often very sophisticated ancient codes functioned to do this. Often more direct linguistic concepts and "rules of thumb" guided individuals and groups – the guidance refined and handed down in tradition.

But in the technology of the last several centuries, this delicate contextual structure was swept away, replaced by a more powerful but at the same time cruder, anti-contextual system, that tended to ignore or even to destroy the contextual structure - often with disastrous results.

The effort to sort out this structural question, and to offer not just simulacra of the past, but new methods based upon the ancient insights and useful for a modern context, would take him on a surprising 30-year odyssey. He would have to confront fundamental scientific and metaphysical questions about the nature of order itself.

My aim here is to give you an overview of this odyssey, and its parallels with the larger changes in scientific thinking about the structure and processes of nature. I will bring this discussion back home to the present day, and the search for useful new tools that can revive and sustain our cities through a daunting new age. We can then assess Alexander's contribution to it, and next steps to be taken.

Alexander took his odyssey beyond human traditions, to ask basic questions about the processes of growth in nature. He made a simple, even obvious observation: nature regularly and almost effortlessly, it seems, creates a vast range of successful living forms, from astonishingly simple ingredients. These structures are exquisitely well-adapted, beautiful, sustainable. What are the processes it uses to do this? And what can we learn from those processes for our own human applications?

To answer that question, he drew on insights from many fields, including embryology, physics and others. And he came to one central conclusion: nature does not use a "plan" in the usual sense, but rather, it acts to transform an existing whole into a new whole. In doing so, it preserves the structure of the earlier whole, but it often amplifies, articulates and deepens it in some important way. We can see that process of transformation very clearly in the biological patterns of evolution. Alexander noted, intriguingly, that we can also see it in our own built history– in the structure-preserving transformations of the Piazza San Marco in Venice over 1,000 years, for example, where at every step, the whole was maintained. At no point was the piazza entirely bulldozed and rebuilt according to some architect's bold new vision. It was rather a continuous evolution, with human plans playing a disciplined role within what could be seen as a kind of "dance of the centuries."

But the steps of such a "dance" can appear deceptively simple and humble– much as a mere 26 letters cluster into words, sentences and soliloquies and create the complex beauty of Shakespeare. When presented with the 26 letters alone we might wonder how we could possibly create something so rich from such modest parts; but Shakespeare clearly did.

So, too, in the process of creating form, as we see all over in nature, the steps can seem exceedingly simple and modest. But the key is in how they combine, how they multiply in repetition-- much like the way two colours of putty will mix surprisingly quickly after just a few repeated folds, or the way a marvellous animal shape can result from just a few relatively simple steps of folding paper in Origami. There is an exponentially multiplying interaction between the parts, which manifests over repeated steps.

It turns out that this is very much how forms develop in embryology, through a very similar kind of "unfolding" process. This occurs not only in the DNA and RNA molecules, but also in the protein structures that they then form, that subsequently bend, fold and interact, and form various products, including tissues. These tissues then divide, fold, differentiate and articulate into new structures. In addition to the simple parts – just four molecules in the genetic code– all of this rich complexity comes from relatively simple steps too: combine, divide, fold, merge, and so on.

This "complexity out of simplicity" is a key to understanding the processes that create richly articulated, differentiated, living structure. It is at the heart of what biologists call "adaptive morphogenesis"– underlying the creation of thriving, stable ecosystems.

This was a major revelation for Alexander. It was not lost on him that age-old human processes share some aspects of this structure. He observed the way traditional craftspeople took relatively simple steps to gradually weave stunningly beautiful patterns in carpets, or the way traditional city-builders took small steps to position their houses and the spaces around them, gradually building up a marvellous urban structure with exquisite traits.

Our "modern" methods, he noted, are based on a very different, radical approach: creating templates and "blueprints" ahead of time, which can be thought of as little fully-developed models of reality. They produce powerful economies of scale because they allow for standardised repetition. But they also tend to impose rigid artificial aspects on the reality, instead of adapting to it to the very fine degree that nature requires.

Nature too uses templates, on occasion, or something like them. One might think of DNA as a kind of blueprint. But nature is much more subtle than current human technology: there is no little model of a finger encapsulated in the DNA molecule; it uses a strategy that is at once far simpler than that, and far more complex and sophisticated in its output. For every finger produced is a marvel of uniqueness, sophistication and complexity. The human version of a template, though it has been enormously effective in conventional technology, is a far cruder and less elegant device. The implications of that are significant.

THE NEED FOR A MORE ADAPTIVE TECHNOLOGY

Perhaps an even more sophisticated, more "modern" approach, would re-integrate these other powerful processes into human methods – including the powerful if often unconscious processes of human tradition. Perhaps nothing less would be required to create the kind of well-adapted, sustainable, balanced structure that nature had done, and that was beginning to look like an essential requirement for a prosperous human future.

Alexander came to see that even his pattern language was guilty of the "template" limitation. If people used the language to come up with a design, planned in advance, without a careful generative process for adapting the form, then the form simply wouldn't have that living quality that was needed, and that was achieved by previous generations across so many cultures. The reform of our unsustainable modern processes of morphogenesis was still incomplete.

ALEXANDER'S OBSERVATIONS ON THE NATURE OF ORDER

Alexander asked himself, what were the methods that people could use to apply these kinds of processes to acts of building (and other form-making) in a modern age? What insights would they be built upon, and how would they function? And over the last several years, Alexander has released his four-volume work, The Nature of Order, which lays out his answers – or at least the first part of his answers. As I will discuss shortly, there is still a major element of work to be done.

Here I will outline several of the key concepts of this work.

Centers

One needs a useful diagrammatic model of the structure of things that is undergoing a pattern of growth – an analytic understanding of the essence of what is going on geometrically. For Alexander, that model is a system of centers. Every form can be understood as a system of centers in some relation to one another – one inside another, one forming part of a boundary around another, and so on.

A system of centers can have a hierarchical relationship, a networked or semi-lattice relationship, or some combination. It can have all of the kinds of relationship that Alexander

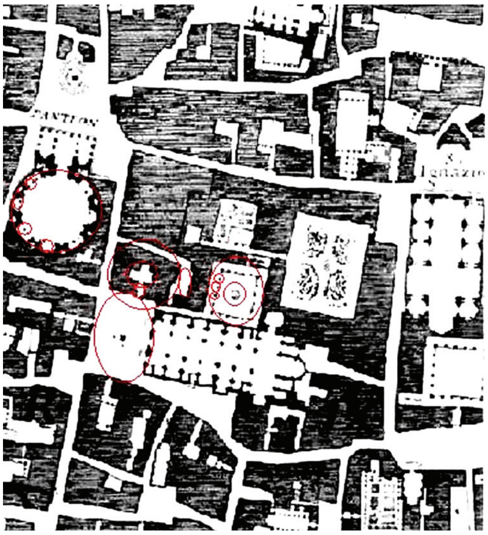

Fig. 1: The Nolli Plan of Rome, which can be analyzed as a series of nested (hierarchical) and overlapping (networked) centers.

and other theorists described, in critiquing the limitations of modern design methods.

Thus the model offers a powerful way of modelling the structure of form, and the transformations it undergoes– and also its limitations. There are echoes of Alfred North Whitehead's "Categoreal Scheme", and echoes too with theoretical physics. There is also an echo in the work of Herbert Simon and The Architecture of Complexity. But there are also unique insights that have gone on to prove themselves useful foundations for the rest of the work.

Fifteen Properties

Alexander then made an interesting observation: in spite of the endless variety of configurations in which centers can be found in nature, he found that one can distil them down to just 15 different classes of organization, or geometric properties. Every form of structure that he was able to observe could be grouped into one of these classes. This scheme of classes turns out to be very useful in analysis and, Alexander believes, in aiding as a design tool. I will outline the 15 classes here briefly.

1. LEVELS OF SCALE: Structures of centers occur in similar configurations at different scales, often spanning a vast range of scales. This is similar to the familiar concept of fractal structure.
2. STRONG CENTERS: Certain centers will have greater prominence than other, and may attract sub-structures around them.
3. BOUNDARIES: Centers may form linked structures that wrap around other centers, forming a boundary.
4. ALTERNATING REPETITION: Centers may form alternating pairs that are then repeated in chain-like structures around other structures.
5. POSITIVE SPACE: Where structures of centers wrap around and enclose space, that space also forms an efficient structure of centers, without crowded, wasted or asymmetrical regions.
6. GOOD SHAPE: This is in effect the inverse of the above: where structures of centers form larger clusters of centers, these larger structures are also efficient, without crowded, wasted or otherwise disordered areas.
7. LOCAL SYMMETRIES: While the configuration of centers at larger scales can be highly asymmetrical, local areas often tend to form highly symmetrical clusters. The Nolli Plan of Rome (see Fig. 1) is a particularly clear example of this.
8. DEEP INTERLOCK AND AMBIGUITY: Adjacent regions may interlock in a mutually dependent way, to the point that there is ambiguity of one form in relation to another. An obvious example is the optical illusion of a vase-face shape, in which each shape has its own coherent relation to some external structure, or can be seen ambiguously as the profile of a radically different form.
9. CONTRAST: Adjacent regions may be abruptly discontinuous.
10. GRADIENTS: Adjacent regions may exhibit a gradual gradation between them.
11. ROUGHNESS: A region may have a complex structure at finer scales that appears chaotic or "rough"; it is in fact a form of transformed structure at finer scales.
12. ECHOES: A region may exhibit partial symmetries with other entities (symmetries in the most general sense, i.e. isometric configurations).
13. THE VOID: A region may have no centers within it.
14. SIMPLICITY AND INNER CALM: A region may have deceptively few centers within it, with a surprisingly strong effect upon a viewer.
15. NOT-SEPARATENESS: Every region is linked ultimately to all other regions, including the viewer and their world, and ultimately the cosmos. The property of not-separateness exhibits this linkage to the viewer, which can evoke a profound feeling in response.

Alexander observed and reported the 15 properties phenomenologically, but then began to seek clues to their underlying formation and arrangement. He came to understand that they arose naturally as a result of the natural transformations in the processes of morphogenesis. That is, the process of structural development leads to these classes of order, through the workings of the transformations. (There is more detailed discussion of this in *The Nature of Order*, but I will not go into it here.)

Alexander pointed out that the 15 properties can be seen all over the natural world. Interestingly, he noted that many contemporary structures lack one or more of the properties almost entirely. This is because, he argues, current processes of morphogenesis are highly limited and artificial, as they are affected by the limitations of human thinking, and the segregation of "planning and design" as an abstract function, from the rest of the process of morphogenesis. Once again, the "template" approach is showing its drawbacks as well as its advantages.

Structure-Preserving Transformations

We mentioned the notion of transformation earlier. This is a more complete description of the general process. It is best illustrated with the following example.

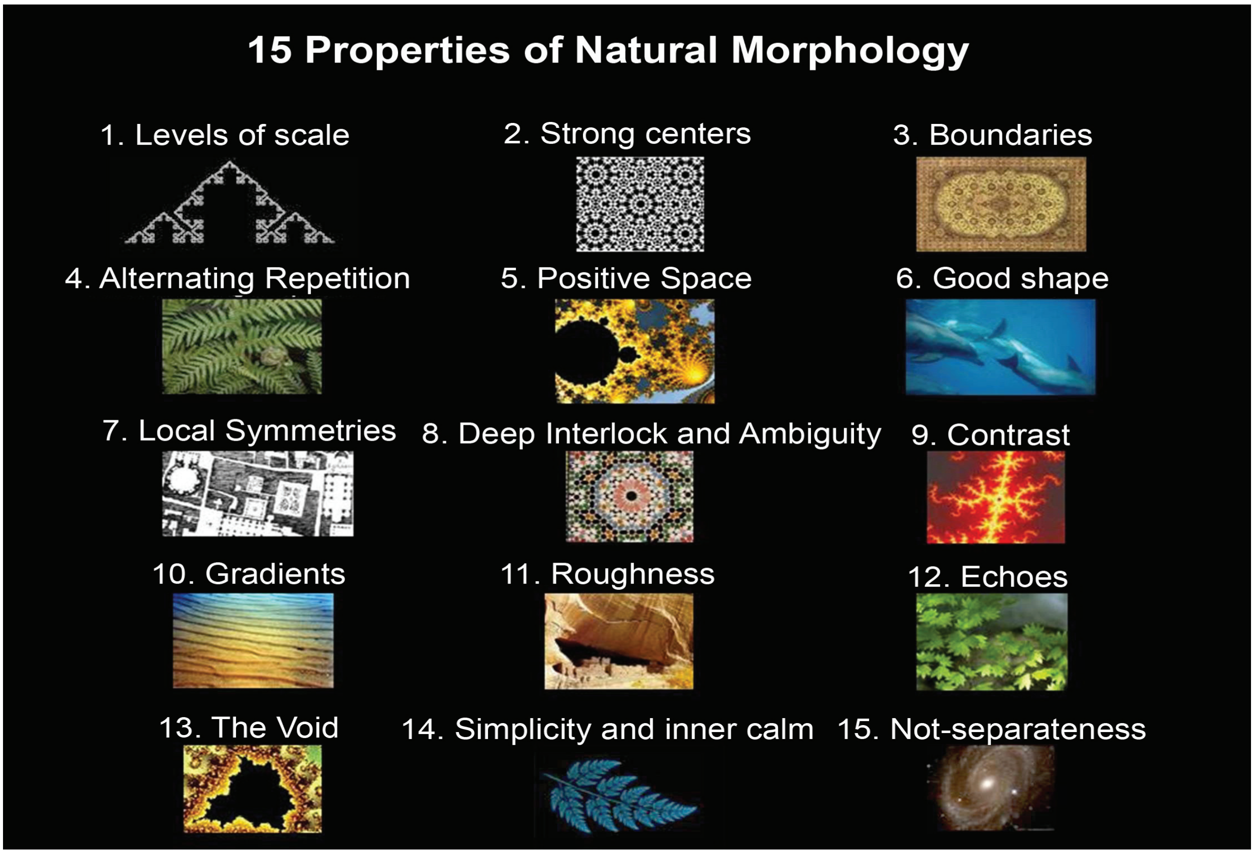

Fig. 2: The 15 Properties of Natural Morphology in which centers may be structured.

The series shows a drop of milk hitting a thin layer of milk covering a hard surface. Note the initial sphere, a simple center in the middle with no articulated centers around it. It strikes the surface, and its symmetry is immediately broken. The result is not chaos, but a new kind of organization. The displaced milk rises up and forms a ring, a boundary around the original drop. The ring expands, and as it does so it too becomes unstable– the equilibrium between gravity and velocity is exceeded– and its symmetry is broken as well. But again, the result is not chaos but the articulation of new structures– arm-like appendages, and at their ends, like exclamation points, new baby spheres (Fig. 3).

The overall structure exhibits the features of organization, not unlike an organism. There is a unity of form without the overall composition. There is a hierarchy between the center, the ring, the appendages and the small spheres. There are interconnections between the different arms, which can be seen to slightly perturb each other. There is an irregularity too, which is intricate, varied and unique – not exactly like any other milk drop. It is not a perfectly repeated pattern, but it is a well-organized one all the same.

What is significant is that this structure has arisen as a direct result of the steps in the transformation. The structure of the original sphere transformed into the ring, which transformed into the appendages, and finally to the little spheres. It did not simply disappear, to be replaced with a new structure inserted into the environment, assembled from parts according to a template. That is the exceptional, limited and extreme method that is unique to contemporary human beings.

Nature of course is full of far more complex examples – perhaps nowhere more than in embryology.

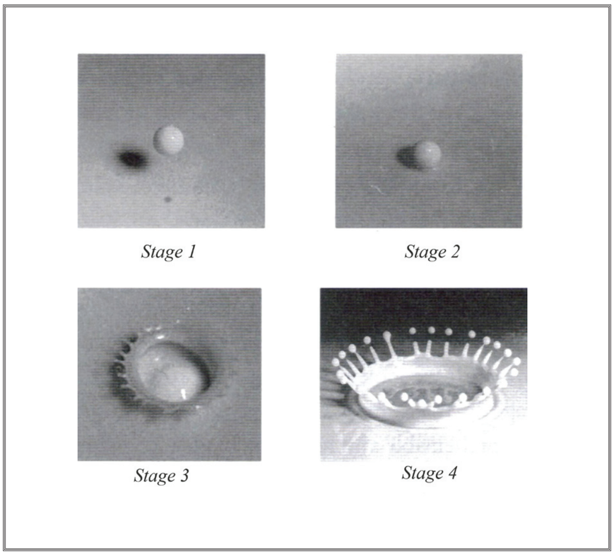

Fig. 3: The structure-preserving transformation of a simple milk drop.

Unfolding

We are learning a great deal about the processes that occur in the morphogenesis of organisms. Again, we see that there is no simple "blueprint" within DNA that contains a little image of the structure to be built. Rather, DNA is a code that functions more like a recipe that drives sequential mixing, dividing, folding, separating and articulating of new structures, from the protein structures to the structure of cells to the structure of tissues and body parts. There is a process of unfolding, not unlike the sequential folding patterns of Origami, which creates various symmetries and transformations of parts.

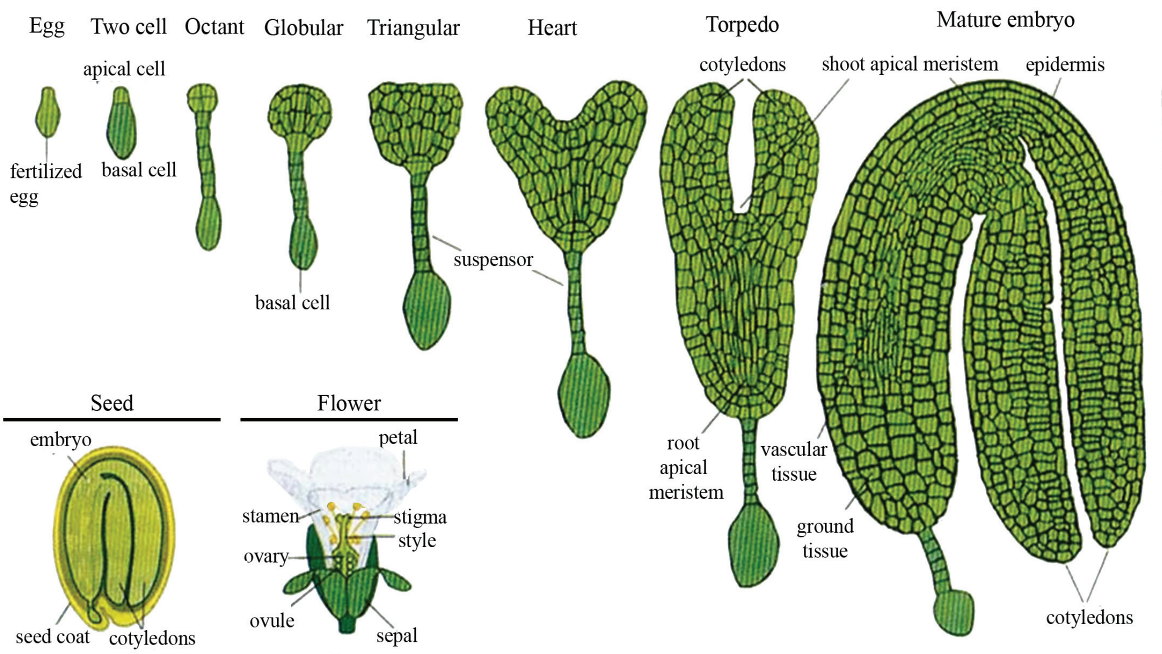

Fig. 4: Morphogenesis in biological processes - Development of an angiosperm seed: Shepherd Purse

What is interesting for our purposes is that the DNA in some way guides the process, like a recipe, with instructions for the various steps. A similar process can be observed in human processes, including cooking recipes and medical procedures. The steps are very simple, but their effect becomes sequentially more profound, resulting in a delicious meal, or a process of complex healing. Urban environments, too, reveal a similar kind of process.

A similar process can be observed in the function of traditional urban codes. Relatively simple rules guide builders through various steps of construction, specifying contextual responses, such as position of windows relative to previously built windows, and so on. The result is an emergent, contextual form. Alexander has found that traditional building processes used a similar kind of stepwise guidance, or "rules of thumb."

THE RE-INTEGRATION OF THE QUALITATIVE

Alexander is hardly the first to note that methodologies since about 1600 have discounted the qualitative aspects of experience, regarding them as "mere" psychological phenomena. This was an extremely useful tool to dispense with highly variable and unreliable phenomena. But modern science has come up against the limits of this tool, which is in fact a kind of trick – what the philosopher and mathematician Alfred North Whitehead memorably called "an omission of part of the truth." In fields as diverse as neuroscience, anthropology and medicine, the qualitative experience of value has made an insistent return to the scientific purview. Perhaps nowhere does this re-integration seem more necessary than in the fields of the human environment, where "quality of life" and "the quality of a natural environment" are hardly trivial aspects of what is going on. Indeed, they are increasingly being seen as the very essence.

The realm of medicine is already largely sympathetic to this point of view, for in fact it has no alternative. The first thing that a doctor does with an ill patient is not to run a battery of quantitative tests and analyses, which would quickly turn into a kind of medical snipe hunt. Instead the doctor knows to ask the simple qualitative question, "how do you feel?" In effect, practitioners in the built environment must do likewise.

For Alexander, the qualitative is not some trivial psychological side-effect, nor is it some mysterious unseen realm. It is quite literally right before our eyes, in the structure of things. What we call "matter" is matter precisely <u>because</u> it "matters" – it has a qualitative experiential effect upon us, and only then becomes a "fact". As Alfred North Whitehead observed, this is the actual order of things, and the customary inversion of it is a trick, an abstraction – "nothing other than an omission of part of the truth."

Thus, Alexander sees quality as an emergent phenomenon in the structure of the world, no less than life itself. Living structure inherently incorporates, or has aspects of, the qualitative as well as the quantitative, in equal measure. We cannot separate them, except in the most temporary and provisional way, if we really want to understand what is actually going on in our world.

This is not inconsistent with a view emerging among many complexity scientists, who have concluded that significant further scientific progress is not possible without such a re-integration of the qualitative. The biologist Brian Goodwin in particular, a former Board member of the Santa Fe Institute, has written eloquently about the emerging "science of qualities", tracing its roots back to Whitehead and beyond. Alexander fits well within that emerging tradition.

GENERATIVE CODES

Alexander has proposed that steps of "unfolding" similar to those in nature could be established today in a modern technological context. Such steps would amount to a modern "generative code", very different from the parameter-based or use-based codes of conventional practice. A generative

EACH STEP IS ALWAYS HELPING TO ENHANCE THE WHOLE

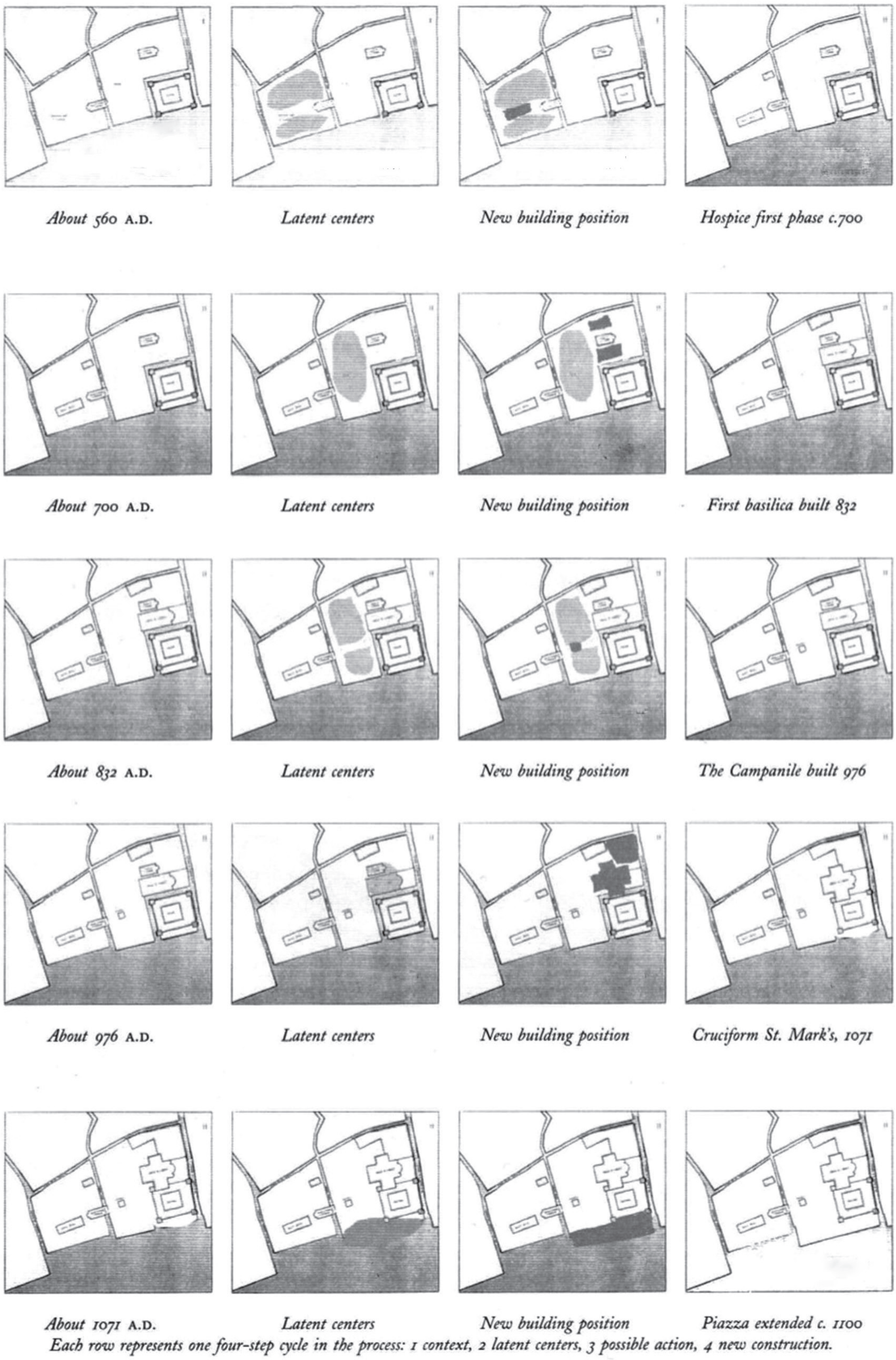

Fig. 5: Structure-preserving Transformations in Piazza San Marco in Venice over several centuries.

code could be thought of as a new kind of design-build "operating system".

In such a generative code, the design phase would no longer be a distinct segment from the construction phase; instead, a stepwise process would guide designer/builders through the sequence of construction, and indeed, on to maintenance and repair.

Because the process is a transformation of existing conditions, and not an insertion of a radically new template-based design, there will be a particular emphasis on diagnosis of the existing conditions and the changes needed. This process is necessarily qualitative. Moreover, it must involve not only expert practitioners with a range of areas of expertise, but local residents, who can serve as "canaries in the coal mine" to detect important qualitative and contextual issues.

In design-build systems, cost management frequently arises as a major concern. Many items require ordering in advance to be cost-effective. Many items cannot be changed during construction except at significant cost. There is always the grave danger that the process will "paint itself into a corner," and changes will be highly wasteful and cause delay.

But there are methods that manage costs and capture efficiencies comparable to more conventional processes. First, while the process is stepwise, it is not reversible. A decision that is made at one stage is not revisited later – only the finer articulations follow. An organism that has formed, say, an arm, goes on to form hands and fingers; it does not go back and change the arm.

Second, technologies are already evolving rapidly toward design-build and adaptive methodologies. A century ago Henry Ford stated that a buyer could "have any color as

Fig. 6: Examples of Alexander's projects using generative methodologies. The individual forms may appear simple and even humble, but the complexity arises from their interconnections rather than from extravagant attempts to create novel forms. The result provides ample creative novelty, but at more subtle experiential scales.

long as it was black." Today a buyer can virtually create a custom car from the showroom. Just-in-time delivery is making it unnecessary to order and stockpile materials in advance to capture economies. One-off processes and niche marketing are moving the economy toward much more adaptive processes.

But much more work remains to be done to develop functional generative codes – and a number of pilot projects are already under way. For example, the form-based code of Andres Duany and others, called a "SmartCode", is being supplemented with generative steps for diagnosis and layout. One of the most hopeful efforts in now under way in New Orleans and on the US Gulf Coast in the wake of Hurricane Katrina, where "Neighborhood Rebuilding Centers" are being developed with generative tools for the rebuilding of neighbourhoods. We do hope that there might be opportunities here in India for a project.

What are the elements of such a generative code? We can broadly summarise them here:

1. The code, in some way, specifies a step-wise, generative process.

2. It specifies that in that process, human beings will take certain rule-based actions, in combination with evaluations based upon feeling, and in adaptation to what came before.

3. At each step, it acts upon the then-existing condition as a whole.

4. At each step, it identifies the weakest parts of the structure and acts to improve and amplify them.

5. At each step, it may apply previously-coded solutions and patterns, and adapt them to the novel conditions.

6. At each step, it differentiates the space by specifying new "centres"

7. The centres are differentiated via 15 "structure preserving transformations"

8. Infrastructure follows. As with the morphogenesis of organisms, where the tissues come first, and the veins and ducts follow, the human patterns and human spaces come first, and then transport, sewers and the like follow – not the reverse.

9. Similarly, visual expression follows. The human patterns come first, and then the visual ideas and "signifiers" follow – not the reverse. Otherwise we are simply making people live in disconnected sculptures, however worthy as such.

10. At the end of each cycle, the result is evaluated and the cycle is repeated.

THE IMPLICATIONS FOR THE REGENERATION OF TRADITIONAL SETTLEMENTS

Clearly it will not be enough to consign a few traditional structures to fossil-like preservation in museums, while the rest of the world is continually swept away and re-invented in a shiny new form. As I think this discussion begins to show, such a *tabula rasa* approach, which once seemed so modern, is a relic of the science that underlay an earlier industrial age. We now see that it is inconsistent with the evolutionary processes that produce adaptive morphogenesis, and achieve the sustainable equilibrium we seek. It is unsustainable, and it threatens our very survival.

The evidence is increasing that we must re-assess and reform our methods of producing environmental structure. We must create a more sophisticated, more evolutionary kind of "operating system" for growth.

Nor, this discussion suggests, will it be enough to merely copy the traditional structures from another time, including urban structures or urban patterns. As we see, there is always a transformation going on in any living process, and to keep traditions alive we must also revive the evolutionary processes that produced them. Tradition, as Goethe observed, is the tending of the fire, not the worship of the ashes.

Much remains to be done, and we are keen to discuss opportunities for further development. But Alexander's hopeful message is that the patterns of a more healing kind of growth are already all around us. We can find them in the structures of nature, and the processes that produce them. We can find them in the collective intelligence of traditional structures and traditional knowledge, ready to be revived and regenerated, as part of the living tissue of our globe. The writer Jorge Luis Borges put it best, "that between the traditional and the new, or between order and adventure, there is no real opposition; and what we call tradition today is a knitwork of centuries of tradition."

Let us only resume that knitwork, and discover the renaissance that nature offers us.

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