Sustainability and Morphogenes is

The Rebirth of a Living World

A much-expanded version of the

SCHUMACHER LECTURE

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by

Christopher Alexander

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THE LECTURE

INTRODUCTION

PART 1: THE NUTS AND BOLTS OF SUSTAINABILITY

The core issues of sustainable development, as presently understood, are very roughly the following. They may loosely be grouped into technical and philosophical issues and I have grouped them in this way:

Technical issues

- Protecting and recycling all natural resources
- Saving soil and water resources from exploitation and erosion
- Taking measures to protect planetary climate stability
- Reduction of wasteful energy consumption
- Using appropriate "green" building materials
- Developing renewable non-destructive cycles of food production, material production, and land management.
- Development of non-destructive energy sources such as solar energy, tidal energy, and wind energy
- Water and waste management carried out in a way that recycles water and uses refuse and waste for fertilizing land.
- Recovering and maintaining bioregions.

Social and Philosophical issues

- Protection of vanishing and threatened species
- Birth control to help reduce and stabilize the earth's population
- A good spiritually healthy relation between inhabitants, users, communities, and their environment.
- Physical and social health of the environment.
- Protection of the natural ecology of plant life and animal life in their relation to human life.
- The economics of sustainable thinking are introduced to overcome the negative effects of large scale corporate development.

And there are, of course, many others.

Adherence to The Whole

Implicit in many of these widely supported agenda items, lies the idea of adherence to the whole. Animals are as important as human beings, but they are more vulnerable to the ecosystems where they live – a problem of great subtlety which requires attention to many environmental interactions in the local whole. Water resources are finite and must be protected by recycling because, viewed globally, or regionally, there is only one amount of fresh water. Climate

destabilization is a holistic problem which affects the earth as a whole, and must be treated as a whole. The holistic nature of these problems, and many others like them, is widely recognized.

But although these propositions are worded to express their concern for the whole – both globally and regionally – they are less often expressed in an active form which also requires intimate and detailed adaptation of the environment, *at every local level*. For example, it has become common wisdom (not often implemented) that food and materials should be obtained from the local area where they are being used or consumed. But the reasoning for this idea comes from energy considerations – the energy expense of moving these things around, and the consequent damage to the planet from pollution, energy costs, and so on. But the deeper argument, surely, is that there is a very good reason for encouraging a local area to be self contained, as far as possible, except when there are compelling reasons for transactions with other areas and regions. In short, the wholeness of a community, or of a neighborhood, even of an individual building, as a human, and biological system, needs to become a focus of attention.

The following empirical issues therefore lie at the core of this lecture. I claim that when environments are generated by morphogenesis – that is to say, by morphogenetic processes – they will then have the following qualities:

- First, by the very nature of the morphogenetic processes the environments generated will, of themselves, support and encourage contemporary technical issues of sustainable development, but their primary goal will always be the well-being of the whole.
- Second, they will also encourage, sustain, and encompass a large number of key social and philosophical attributes which the adherents of sustainable development have often expressed a wish to reach, but which present day technical methods do not achieve.
- Third, our environment-building activity will step back from its present technical orientation and vision of corporate gigantism as a source of solutions to sustainability, and begin again, from a deeper source. Its primary orientation will be for all society to achieve the health of the whole in the largest sense, and it will seek to develop new solutions based on adaptation and sustainability in the local area, *and* based on a deeper understanding of wholeness.

These three points are the key empirical propositions of my lecture. Stated another way:

(1) When environments are built by morphogenesis they will of their own accord become sustainable.

(2) Among strategies for dealing with sustainability, morphogenesis ALONE can deal with ALL the issues of sustainability together.

(3) The morphogenetic process has the ability to reorient all our efforts, and achieve a deeper (though heretofore hidden) agenda of the sustainable movement – the effective overall health and wholeness of our world – in a form that is more profoundly satisfying, and much more in keeping with our social and cultural aspirations.

PART TWO: THE PROCESS OF CONSTRUCTION

With respect to the built environment, this lecture addresses a deeper issue than most sustainability proponents have recognized. When buildings are created morphogenetically, they participate in restoring the Earth.

But the way in which most 20th-century architects made buildings, was fundamentally at odds with the possibility of morphogenesis – and therefore entirely at odds with sustainability. A world which is sustainable constantly renews itself, and renews the resources that are the underpinning of every process –

the processes which create the world. This requires a massive, continuous, and pervasive process of adaptation. In the era we now think of as "the past", the possibility of this fine-tuned adaptation came about readily, because patient, careful, hand craft was nearly universal as the way buildings were made, and therefore was able to provide the needed adaptation in every doorway, and every roof, and every window.

We have not yet well understood the extent to which this fine-tuned adaptation, necessarily the foundation of every living architecture, was thrown out by the advent of the processes of the 20th century. Because the old technique did not work any more, we assumed, collectively, that we could make buildings in a new way – "a machine for living in", as Le Corbusier put it. The incredible damage done to the world during the 20th century, came about, in large part, because a style, or it might be called a "manner," was taught in architecture schools and proliferated by developers. And the horrible thing about what they all did, together, and by mistake (I mean, without realizing the consequences of what they were doing) was that local adaptation, the beauty and uniqueness of shape and substance, that occurs in a living world, was ripped out of our awareness. We came to accept these deadening things, and I am sad to say, my own colleagues in the field of architecture and planning played a terrible part in it.

So, please be aware, throughout the lecture that follows, that it is the geometric substance, no less than

the content of sustainability, which is at stake throughout this lecture. It is this geometric substance, which is the fundamental aspect of a sustainable world. You could not make a butterfly with lightweight titanium wings, and expect it to remain a butterfly. We cannot have a genuine, sustainable, architecture, unless we have a way of making, shaping, transforming buildings continuously, as part of the process whereby they become sustainable.

That is the necessary goal, of the ideas which are put forth in this lecture. No amount of talking around the point, can overcome this obstacle. And if you find a person trying to convince you that you can have all this sustainability, without morphogenesis, and still keep on producing buildings and roads, and factories, in the "old", "twentieth century" way -- just call their bluff and call it nonsense.

If you are a person who is interested in this task, you must, from the beginning, face the fact that it is the overall system of production that must be changed, to create a living and sustainable world, and that nothing less will do.

Imagine, if you will, a new vision of architecture process, design, and construction. The essence of this new vision, is that everything works, at innumerable levels of scale, and through multi-leveled, layered, processes of adaptation. The window sill is a living thing, which gets adapted to the wall. The front door step is a living thing, which in the course of its creation,

became adapted to the hall beyond it, and to the garden or path, which leads to it from outside.

Each space in the garden, is adapted to the spaces next to it. Each room is adapted to the rooms beyond it, or lying next to it. A bridge is adapted to the stream over which is built; it is adapted to the use of the pedestrians on the bridge; it is adapted to the loads of trucks and cars; it is adapted to be kind and helpful to nesting birds; its bricks are adapted to the arch of the bridge. Or if it is built differently, the concrete elements, or steel, from which the bridge is made, are worked, to create detailed adaptations between adjacent pieces of steel, or concrete. And the pieces of steel are shaped and adapted to the shapes of neighboring elements of steel, to create the kinds of bridge connections which are most effective in channeling the flow of forces.

Like nature, this overall process, if it is happening for every part of every thing in the environment, guarantees sustainability, and is also well-tuned to people's feelings and enjoyment.

Let us try to imagine such a process, working in the 21st century, and helping us bring to existence, a world that is beautiful, and practical, and can be built at the necessary, modest price, taking into account the world's finite resources.

Perhaps even more important, we shall see in chapter XV (pages 166-190), that most of the urgent

demands that sustainable thinking requires, depend for their success, on morphogenesis, as well.

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THE LECTURE

Given before the Schumacher Society of the United Kingdom,
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I Preface

I am on rather delicate ground in what I'm going to say today. I know how much careful thought has gone into the issue of sustainability, and I know that hundreds of advocates and devoted sustainability enthusiasts are sitting in this room. And yet … and yet . . .

In this lecture, I am going to try to link sustainability (in the technical meaning it has recently

acquired, and as it is most often thought of today) with another, deeper meaning of the word, which fewer people think of. This second, deeper meaning of the word, so far removed from the first meaning that it is almost another topic altogether, refers to the wholeness of the land, the extent to which we see our land (urban, rural, or wilderness) as sacred, and the extent in which we treat our interaction with the land as a sacrament. In this second view of sustainability, it is the extent to which we recognize that the beauty of the structures we generate in our land that is a matter of paramount *scientific* importance. This beauty is not just an add-on or a luxury. Rather, it goes to the very core of what sustainability really is. I will try to explain why I think so, and what that involves.

It is important, too, for me to make clear that what I mean to point to with the word "sacrament", is not a religious concept, but a *scientific* view about how systems interact, and behave, and the way that the wholeness of any system unfolds (if it is allowed to) in a way that comes directly from its own nature.

Coupled with this, of course, there is the issue of spirit. What I'm going to say about these matters has little to do with conventional religion. It centers, rather, on empirical findings connecting the process of morphogenesis (the development of form in organisms and other systems) to issues which deeply touch us — regarding the human soul.

What has been worrying me about our current view of sustainability is the enthusiasm for technical gismos and for technical analysis and solutions, whether it be in the realm of transportation, or in the realm of air quality, or energy, or water, or many other practical aspects of sustainability. Of course those things are in themselves sound, but as they are understood today they are very one-sided -- damagingly one-sided. And so a world built according to the present sustainable paradigm, the technical sustainability paradigm, would be quite a horrible place.

If, for example, you look at the built world only in terms of money, you run into terrible problems. If you were to look at everything in the environment only from the point of view of structural engineering, this would be hopelessly one-sided, too, and one couldn't accommodate what happens to cows in a field, or what happens to children with their mothers. So you really cannot deal with things from the point of view of one particular limited perspective and hope to see the whole.

Our present technical view of 'sustainability' — with a primarily technical focus on renewable resources — is such a one-sided perspective. Of course, the issue of making sure that resources are renewable and taking care that we don't run ourselves into a dead wall of energy, food, and water, and damage the planet as a system, is of colossal importance. I do not in any way wish to belittle it. But this current technical view of

sustainability is nevertheless very one-sided, and therefore dangerous.

I hope to persuade you to move, with me, in a direction which is less narrow, and less dangerous.

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Finally, please let me give a small warning and an apology. In this lecture please forgive me because I'm drawing many things from the four books of *The Nature of Order*, some of them may be unfamiliar, since the books have only recently been published. There is no way for me to summarize 2,000 pages in 40 minutes. So if some of it seems unclear, or too fast, please examine a slower and more detailed version in the four books.[1]

II Introduction To Morphogenesis

Things in the biological world, almost by definition, are created continuously by morphogenesis, that is by a process which systems are all the time growing and adapting, whether they be in a growing embryo or in a forest or in a field, and which gives form, progressively, while growth and change and adaptation are happening.

In real morphogenesis the form of what is coming, or what is about to be, is always drawn from

the form of what was in the moment just before. Things are always going like that. If a tree is growing for 500 years, it is continuously unfolding from its previous state, and then what we see and recognize is first of all in itself a process. But even if you just look at it in its static state, it is at that moment the end product of transformations that have been going on, and on, and on. And these are the things which give it shape, form, and substance.

Traditional society also managed to do something very much like that – that is to say, morphogenesis -- with buildings, plazas, streets, fences, windows and so forth. And I shall show many examples of this phenomenon. But the point is that up until somewhere around a hundred years ago -- until it started to get off the tracks -- a human-inspired version of this natural morphogenesis, was going on whenever something was built. This was true of fields, forests, churches, houses, streets, even a window or a bench. Whatever it was, it was shaped, modified, shaped again, and adjusted and so on, and so on, and so forth. As a result of the morphogenesis and the complex adaptation that was possible under these conditions, the places people made had life.

The idea that we have inherited from the thinking of the last years is that when you build something you make a plan which is so detailed that it can become a specification for a contractor and protect you in a court of law if something goes wrong with a

particular line of bolts. This legal reasoning began to dominate architecture and construction – and as a result of accepting it, we slipped into a fiction which was that it is actually possible to make a blueprint of a piece of the environment or the completed environment, and have it work. *This is a fiction*. It is very clear that if it was applied to a human being or a daffodil it wouldn't work. Well, you can't make a daffodil that way, you can't make a human being that way even if you had all the micro tweezers in the world and a stack of blueprints that thick, and tried to assemble it. It's just a nonsensical idea. Because morphogenesis is of the essence in the way a thing achieves not only its beauty, but its adaptive resources and its organization, which is beautifully adapted internally. And this morphogenesis happens at a tremendous number of levels. It's not just something large, it is happening at the cellular level, it is happening at the molecular level, it's happening in the limbs, it is happening in the skeleton, and so forth. I mean that hundreds of systems at different levels of scale are all adapting, moving forward, adapting again, and so forth and getting their shape in this way.

Now my hope in giving this lecture is that those of you who share perhaps an uneasiness about the too technical nature of sustainable architecture and sustainable thinking, that somehow by putting a model before you which deals with the very things that you have this uneasy fear about, about where it's all going, could be reassured, re-established in a different way.

And that there then is a real chance of making the Earth precious, as it once was, and as it still is in various places. But also we have to face the fact that it has been desecrated in many places. Even for those enthusiasts of sustainability a wind turbine four hundred feet high may sound like a very good idea because of its potential impact on renewable energy. But if it is also a desecration of a quite a large piece of land, it's a bit of a problem.

We need to think about these things in a way that puts them in balance.

III Techno-Sustainable Architecture

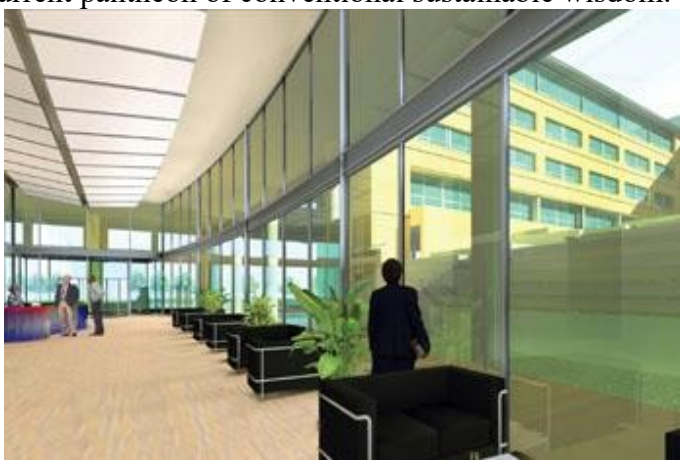
Now I think I'll start showing pictures. First of all just to be clear about what I was just saying with regard to "techno-thinking," here are some of the better-known examples. The first is William McDonough's Ford plant in Detroit.

For d Plant, Detroit

It has grass on the roof, and somehow this was viewed as a wonderful step forward in sustainability. Now I don't argue that putting grass on a roof might not be a step forward. It is a perfectly sound idea, and one that has been used for thousands of years. But is there any sense in this picture that this piece of grassland grew out of the land that was there before? That this

was made to respect whatever land there was? This place doesn't have that kind of atmosphere at all. Without meaning to malign Mr. McDonough, at all, I think I have to make a guess that this was simply not in his heart when he did this.

Here is another important building from the current pantheon of conventional sustainable wisdom.



Interior of the IBM building, Amsterdam

IBM headquarters, Amsterdam, William McDonough

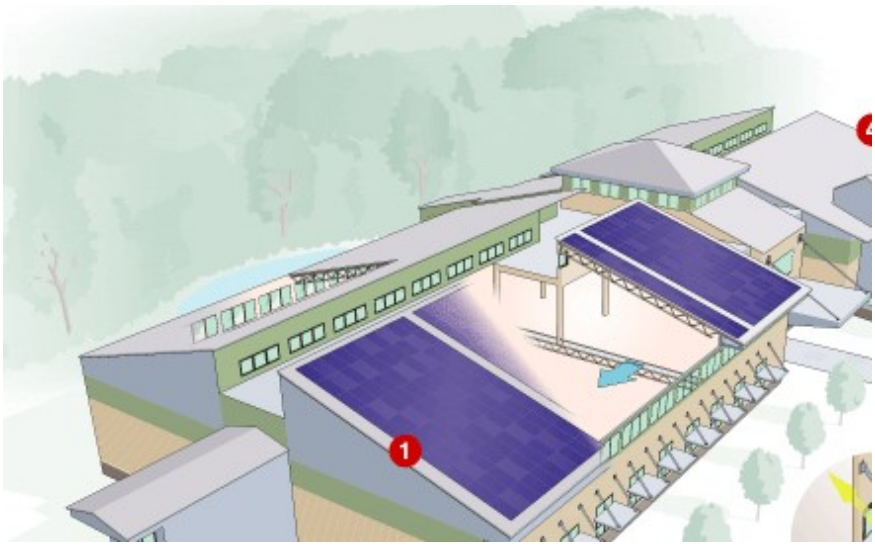
This is in Amsterdam, the IBM headquarters in Amsterdam. Now this building may indeed have good materials or special ways of handling heating systems, perhaps water and so on. But its failure to honor and enlarge the land is really quite bad.

And here is another famous 'green' building at Oberlin College.

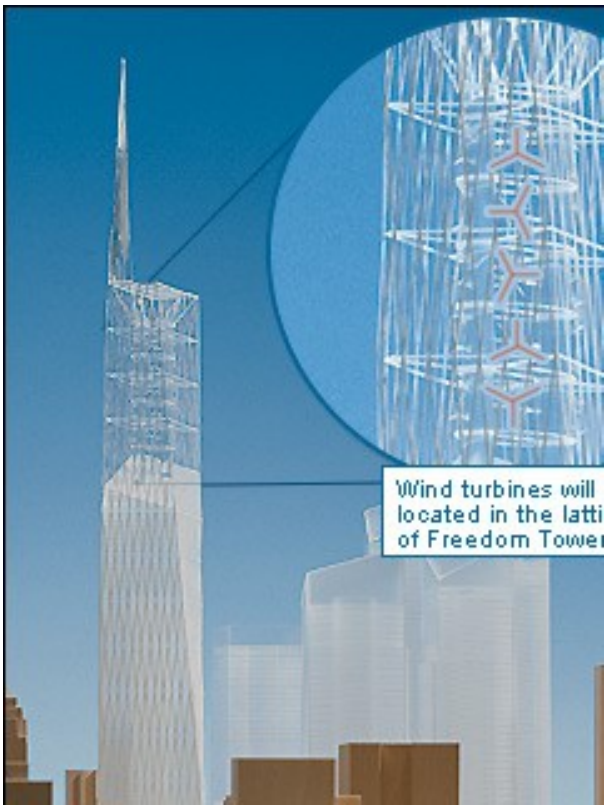
David Orr, the Science complex, Oberlin College, Ohio.

What is positive about this building, is that David Orr has very, very carefully chosen the materials. That is an important and good thing. But these sorts of landscapes! Is this what we want of the Earth? I wonder how many of you think so? I do know that the situation is urgent. And, I suppose in a slightly simple-minded view one might say the building has a nice curve on the roof and is making an effort to be harmonious with the place where it is. But this is still really a very, very shallow nod to a deeper, genuine, heartfelt effort to make the building honor and respect the land.

On the next page, I show further energy-saving buildings. The last one is a little bit different. Again carried away by the enthusiasm for producing wind energy, one could say "Gosh, this is a step forward". But again, I don't think so. These projects do not help the land, nor do they support human feeling. Above all, they do not beautify the land in its own terms.



Cambria project



Freedom tower, Gotham

On the next page is a photograph from the recently built BedZed project in Sutton, outside London. This is perhaps the best and most imaginative, and most sophisticated sustainable housing that has been built so far. Yet even so, elegant and inventive as it is, it is still a technical product, which lacks the deeper properties

of something truly living. It is still a factory product, more than something *truly* sustainable.

Bedzed, a zero-energy development of 100 apartments at Beddington, Sutton, near London. Architect Bill Dunster

Bedzed from the air

Another solar panel, the archetype of techno-sustainability

IV Respect For Land & Morphogenesis

In contrast to the previous highly technical pictures, here is a very ordinary bit of a not-very

picturesque village in Sussex, about a mile from where I grew up, in Chichester.

Here is an example of a small corner of the world, in West Sussex, southern England. It is the bridge in East Lavant. I have chosen this example of adaptation, because it has several illuminating qualities.

- First, it is very ordinary – unpretentious. It is not a beauty spot, but an ordinary corner of an ordinary village.
- Second, it is fair to say that the adaptation visible in the picture has taken place over a period of several hundred years, and is still going on today.
- Third, it is, in my eyes, very deeply adapted. One feels its quiet harmony. Standing there, one feels this quality far more strongly than the thing

we experience when we are merely looking at the photograph.

If you examine the picture it is pretty clear that there is a kind of rambling, gentle structure, very unlike the rigid structure of planned towns and buildings or the planned devices we know from the construction of modern times. It has a more organic quality, something that we typically find in living systems, landscapes.

Yet the "rambling" quality is not loose or chaotic, and is not undisciplined. On the contrary, there is a living orderliness of a kind highly unfamiliar in the 20th and 21st-century world. Each element, no matter how unpretentious, has somehow been fitted in place, and put together with other elements, so that the whole has become progressively more unified. We do not know exactly in what order the successive adaptations took place. And we do not know, precisely why, or on what basis the adaptations were carried out. Yet it is plain – we can see, and sense, merely by looking at the structure -- that the adaptations did take place, by the thousands, step by step, over time.

Look, for example, at the green bush to the left of the picture, above the flint wall. We can tell that its shape is purposeful. But why it was shaped as it is, is not entirely clear. It might have been to create privacy for the house behind the wall. It might have been to create shade, or a softness of light. It might have been because the beauty of its shape was pleasant to the eye, seen from the house. Or it may have been done as it is,

because this looks best from the street. It may have been something about the health of the bush.

But this bush, the white railing, the odd, nearly awkward irregularities in the brick parapet of the bridge on the far side of the road… the patches of grass between the asphalt surfaces of the path, the white lines marking the center of the road, all have been shaped, in relation to their context, and have, somehow found a shape which make the whole work better. In most of these cases, we do not know exactly in what sense it works better. The precise nature of the purpose, and of the fitness, or comfort, sought, and achieved, is not necessarily clear. But it is clear that it has been made in this general way, and with this general aim in mind, over a very long time.

We know, too, that the whole thing is stable, and unstable, in an odd mixture. We see that the configuration achieved is somehow stable. It has "settled down." It has reached a kind of equilibrium. But what exactly do we mean by saying this. It is also clear that the configuration we are looking at is not stable or fixed, at all, in its detail. The trees have grown. Things are happening constantly, and being repaired, or remade, differently from the way they were before. It is safe to say that this scene would have been different if photographed 10 years earlier; and very different if photographed 20 years ago, or thirty years ago. Thus it is not stable in a static sense, but rather evolving, changing, and moving in its detail, all the time..

On the other hand, in spite of tremendous changes over a period of two or three hundred years, it is also safe to say that some deep configuration has remained roughly unchanging. The wholeness, the position of the river, the bridge, the road, the major buildings ahead of us (even if their profile may have changed in detail), are all much as they were, and the particular unique quality of this central spot in East Lavant would have been recognizable even centuries ago.

How very different that is, from the rape of modern development, where buildings and roads and parking lots are brutally thrust into existence, and where familiar places are rendered unrecognizable, so different, as to be, in fact, utterly without relation to the past – changing almost randomly, in their crude disrespect for land, light, air, and vegetation.

Can we understand the idea of adaptation, accurately enough, and profoundly enough, to help us get a grip on this problem, in the real world, which faces us every day.

A street in Jaisalmir, Rajasthan

Here is another such place, this time in India, in a small town called Jaisalmir. Shown here is a lovely kind of street with houses where small and important adaptations were going on within a simple and very elegant framework. But you can see from what people are doing here, and how they look, that something has been achieved which roots people in the land.

I am sure that you can feel, intuitively, the great difference between these harmonious examples, when compared with the high-tech examples I showed on pages 30-38.

These harmonious examples are really models of sustainable structure, and they convey an idea of what it means to say that a building, or community, honors and respects the land. *But that is not what is happening today, under the rubric of sustainability! Indeed, one has to ask if the Amsterdam IBM building could aspire in any way whatsoever to this sort of harmony in the land.*

But in these two harmonious examples, you can see the depth of adaptation before your very eyes. In the Indian example, you see the active relation between people and place, so that you know the place is inhabited, shaped, modified, by these people – adults and children – who live there. It is theirs, and to the extent possible, it is sustainable because they make it so. It is the condition of their continuing life. In the English village, you can see how every stone, and brick, and parapet, has been slowly modified, to make it fit the needs of the moment, so that what is left behind is a residue of profound – yet simple and unpretentious – adaptation.

V Casy's Soliloquy from *The Grapes of Wrath*

To bring the point home, I want to read you a passage from Steinbeck, a very short passage, quite a

beautiful passage. It is from *The Grapes of Wrath*, just before they set out from Oklahoma. Casy, the one-time preacher traveling with the Joad family, is ruminating, trying to decide whether to go or not, and he doesn't consider himself a preacher anymore. And he just talks about his thoughts.[2]

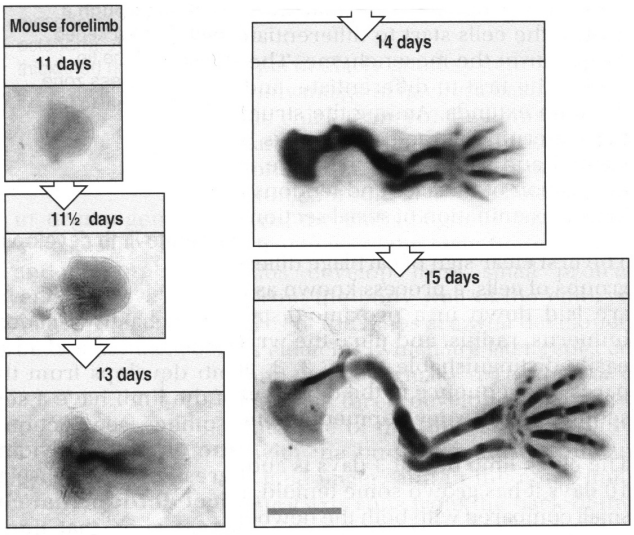
" I been thinkin" he said. "I been in the hills thinkin almost you might say like Jesus went into the wilderness to think his way out of a mess a troubles. I ain't sayin I'm like Jesus," the preacher went on, "But I got tired like him, and I got mixed up like him. And I went into the wilderness like him, without no campin stuff. Night time I'd lay up and look at the stars. Mornin I'd set and watch the sun come up. Mid day I'd watch the dry country. Evenin I'd follow the sun down. Sometimes I'd pray like I always done. Only I couldn't figure what I was prayin to or for. There was the hills, and there was me. And we wasn't separate no more. We was one thing. And that one thing was holy."

If we set our sights to the right place for a sustainable world, that is what we need to be shooting for. The passage of Steinbeck's I have quoted is not theology. That is an ordinary man speaking – though, of course, through the mouth of Steinbeck. It's neither academic nor pretentious. The feelings are feelings that exist in all of us, but in our age we have begun to accept a view in which we have basically been taught (and are often obliged, now, it seems) to forget about these feelings.

Isn't this very down-to-earth holiness – a word not far removed from wholeness – precisely the underpinning of what the movement toward sustainability is all about?

VI Morphogenesis In Nature

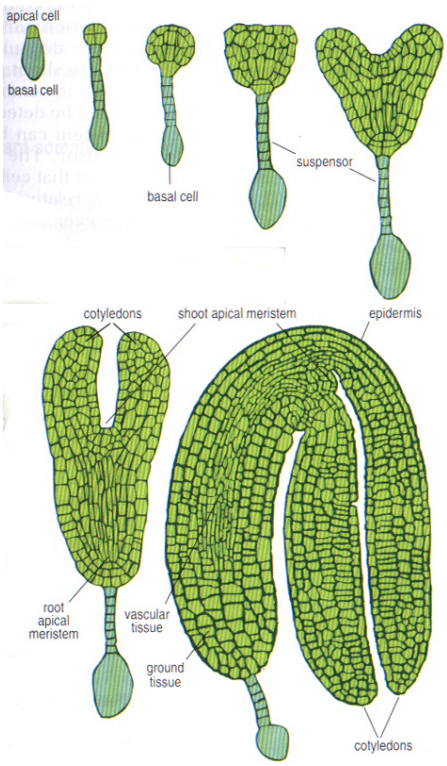
As a background to what follows, let me show a few examples of morphogenesis in nature. First, please look at these shots of the forelimb of a mouse, developing in the mouse embryo. The evolution of the stages shown takes altogether only four days.



Morphological development of a mouse forelimb

At each stage, you have something hardly more than a darkened blur which is differentiated from the lighter gray material around it. Gradually the dark, which is to become bone, starts to settle out and form a configuration, not yet bone, but which is cloudy material that will become bone. It is taking shape. In the third picture (13th day) you see how the two prongs are already there, of these two bones to be. This two-pronged whole is being differentiated so that the whole is enhanced and made more complete.

On the next page, you will see a similar picture, this time a typical flowering plant in the early stages of cell growth. The drawings start with a single fertilized egg cell, and then progress to a 2-celled stage, a 16-celled stage, and so on, up until a stage that has several hundred cells. As it grows, the cells are doubling, growing, swelling, moving and changing shape according to their position in the embryonic plant.



Sequence of stages in the early growth of a typical dicotyledon

As the plant grows, various morphological transformations occur. First the single cell forms two cells, which get differentiated from one another, and form an axis. Then, one end of the axis forms a spherical ball of cells, while the bridge to the other (gray) cell type, increases the number of its cells to form a gray stem. Next, the green ball gets flattened

into a green heart shape. After that, the two parts of the green heart separate and elongate, thus forming the pair of leaf shoots that are typical of every dicotyledon when it is in the seedling stage.

I want to draw special attention to the *enormous* configurational variation from cell to cell, among the individual neighbor cells that are visible within the plant. In the drawing you see the huge variety of cell shapes and sizes, each is unique according to its position. This kind of configurational variation only comes about in morphogenesis. It cannot be generated by a blueprint-driven process; it can only come about from the progressive unfolding of the whole, stage by stage, as each stage arises from the state of the previous whole, and then by the iterated repetition of this process which generates and shapes new cells.

There is relatively little understood about the way this adaptation works, inside the tissue of an organism. Certainly plant morphogenesis is now beginning to be well understood insofar as the chemical and enzymatic processes are concerned. There has been a lot of work done, successful work, on how chemical fields steer the morphogenesis, switch on genes, switch off genes, and so forth. So, in part the differentiation of cells and the way that differentiation works is beginning to be understood. But the overall configuration and it's ability to make cells adapt and cooperate while it growing has not been studied in sufficient detail.

Above all, it has not yet been well understood *from the point of view of its configurations*.[3]

Yet in studying towns or building morphogenesis, what we need to know is precisely this: how does the geometry unfold, in such a way that the wholes come into existence successfully, and can be adapted to context successfully.

A Human Being Growing

Let us survey further examples, to help ourselves understand how pervasive this morphogenetic form of creation is, on Earth. The next series of images are from Lennart Nilsson's movie of an baby embryo growing in the womb. The pictures are familiar. And once again the growth, and form of the emerging child, is defined by its morphogenesis: the sequence through which tissue and structure are laid down. We are familiar with it for a baby. Yet it is only just now beginning to occur to people that the very same processes, or others very much like them, *must* be responsible for the growth of a successful environment.

Opposite: A child is growing. Grasses are growing all over the planet. Is it not obvious that a sustainable environment on Earth, must, also be given its form by society-wide processes of morphogenesis.

The reason I want to show the human embryo growing, and make you sit through the movie for about a minute is because again, all the *structure* of that human being is being created, moment by moment, *through morphogenesis*. Although we fully understand that this is how human beings grow, we have not yet grasped the lesson, that our environment itself, must grow like this, if it is ever to be truly sustainable.

This is simply a new way to think about how the world is formed, and how it should be formed. In fact it

hasn't really been thought about yet. I have spent pretty much all my life trying to find a path to do these things. In the last stages of this lecture, I will show you projects where you can see morphogenesis happening on a fairly large scale in towns and buildings. Before I do that, I am going to show you one more picture of this type in biological systems. Here we see six stills from a film of white hawthorn blossoms opening.


HS 825
TCR 01:19:41:04


HS 825
TCR 01:19:43:01


TCR 01:19:45:02


TCR 01:19:47:02

Here, once again, I want you to think, not that this is just a bunch of blossoms that are opening their buds. Instead, please try extrapolate from the process pictured here, to imagine a physical world of our making in which the transformations that are occurring here, in our world, our created world, our habitable world of every day, is also unfolding, growing, changing, moving towards a more and more adapted whole, in which each state arises from the state before, not by tearing and destroying, but by smoothly growing from what was there before. And then, in the latter stages, the world, the neighborhood, the street, has the same harmony and wholeness and well-being, as the blossoms in this sequence of the buds opening.

It is worth pointing out that the structure here is moving, not only growing. It is moving around, at the

same time that what is created is constantly varying from place to place. These variations here are not caused by the DNA. They are caused by the impact of the different buds and organelles, and the dynamics of the system in which all the parts are acting on each other to adapt cooperatively as this system goes forward in time: *and it is this process which generates the nearly miraculous variations within unity.*[4]

In all these examples from nature, we have examples in which the making of a plant, a mouse, a human being, and a tree filled with hawthorne blossoms grow, give themselves shape, through a process which unfolds gradually. To pick a number to mean "large", let us say that there may easily be five thousand things – cells, organs, tissues, or whatever they – and (if you want to use the word) in the course of its generation, and its construction, each of these five thousand things has been adapted to its context, shaped to fit the context, sized, stretched, enlarged or reduced, twisted, bent, pushed and shoved, to make sure that it fits its neighborhoods, and that it works within the whole. At each moment of its unfolding, this deep adaptation is going on. In what we call nature, the beauty of the Earth – another word for its sustainability – *only* comes from this kind of process.

Something very similar is *necessarily* true of towns and buildings, too. The subtle, efficient, and tender adaptation which makes a place harmonious, useful, and dear to our hearts, and in building

construction and in the making of towns and villages, once again, the beauty of the Earth can only come from some version of a similar morphogenetic process.

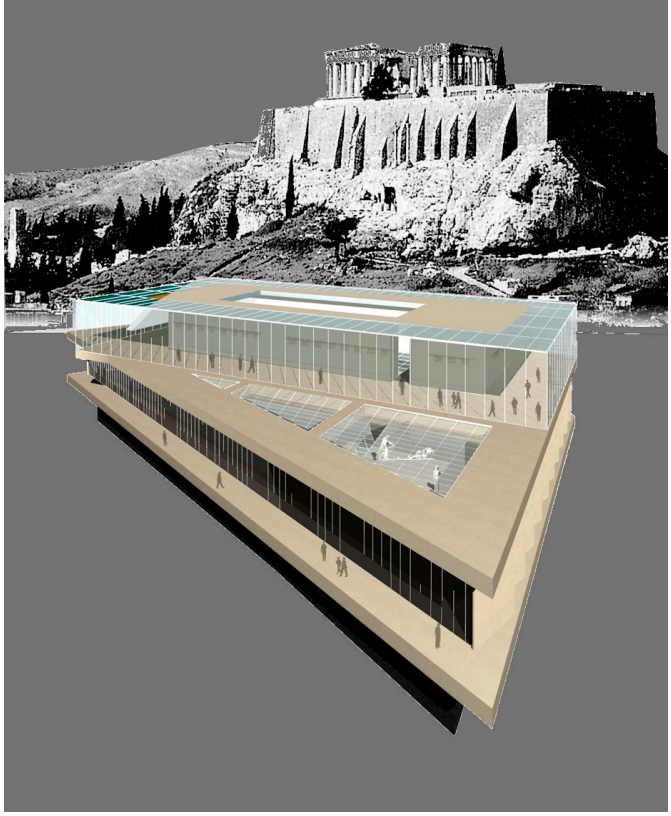
VII The Nature of Deep Adaptation

In England, the magazine *Resurgence* has done a wonderful job of directing our attention towards the living Earth, and away from purely technological sustainability. For years, now, *Resurgence* has been trying to move towards this kind of living thought and experience, and away from the purely technocratic. But the difficulty is to have a coherent frame of thought in which that "something" that is an embodying quality – the down-to-earth holiness of Steinbeck's that I quoted on pages 47-48 -- is actually present when we make streets, traffic lights, buildings, paths, cafes, and so forth. Yes indeed, the issue of "green" materials and so forth, has its place. But this other matter of being one with the land, being what Steinbeck calls "holy," is a very different order of business, something deeper, something more all-embracing, something that goes to our essence as human beings. This is a deeper kind of sustainability, and a deeper kind of sustenance. But, as we shall see, the two are very practically connected.

The Acropolis

The Acropolis

On page 62, there on the rock, stands the Parthenon after centuries of respectful adaptation to the land. And on page 63, is a picture of the proposed new *Parthenon Museum*, in the position it is to occupy,



praised by international architects, sponsors, and well-meaning, misguided, richly-endowed foundations. Why am I so adamant?

Without any deliberate intention, I am sure, the sponsors of the new museum have raped the land, destroyed the beauty and harmony that was built over centuries, with a shallow, money-guided image, to hold the treasures of the ancient Acropolis. And in so doing the Acropolis itself, as a sacred site, is being destroyed. But this shocking museum building and its banal relation to the Acropolis, does have something

profound to teach us about the nature of wholeness, and the way in which true adaptation is dependent on wholeness.

Let us focus on the key principle of deep adaptation: *each adaptation is made by a wholeness-preserving process*, which introduces transformations that leave the wholeness of the global structure intact and enhance it and extend it.

To illustrate the degree of damage done by ill-considered actions, which violate the principle of deep adaptation, please look more carefully at the architect's drawing of the new Acropolis museum (opposite).

The world has well understood, for 2500 years, that the Acropolis is not only the place of the Parthenon, but that it is a sacred site *as a whole*. It is the rock, the relation of the rock to sky, land, and surrounding city, which makes it, and which makes it valuable: this includes the hierarchy of larger and smaller buildings, built over centuries, and the arduous path to the top – all part of the wholeness of the place. The Tschumi proposal insolently and dramatically damages the site, the rock, the surroundings, the Parthenon itself, and the minor buildings of the Acropolis complex.

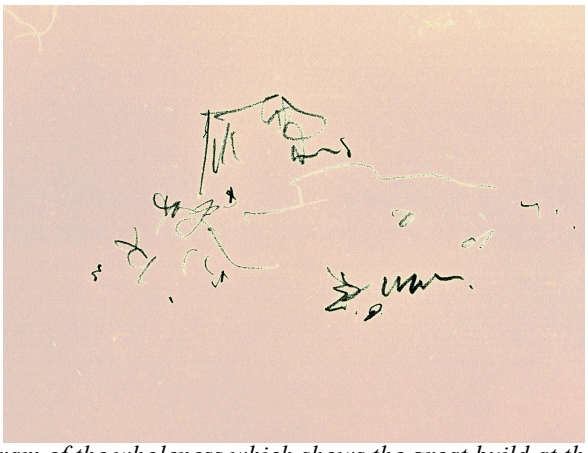


Diagram of the wholeness which shows the great build at the top, the smaller buildings lying on lower slopes of the rock, and placed so that they build up to, and emphasize the Parthenon itself.

All these things together, as they have been, and as they remain today, contribute, respectfully, to the original rock. The structure that we see in the acropolis site, and that exists there, is a structure of centers which may, loosely, be diagrammed as shown above.

The Tschumi proposal introduces a new kind of structure which is not only at odds with the previously existing structure. It violates it, just as a jagged scar can

The newly built Parthenon Museum

violate the structure of a man's face. It sets up, for example, diagonal lines and sharp angles, that are violently at odds with the subtle configuration of centers that are there previously,

Since the difference between wholeness-destroying transformations and wholeness-preserving transformations lies at the root of deep adaptation, I shall try to explain the details of this situation in Athens.

Let us first examine the wholeness of the Acropolis, as it existed historically, and as it still exists today. First, a definition. The wholeness of a given configuration, is a structure of symmetries and centers which captures the largest gestalts present in the

configuration, the over-riding forms and configurations which are the impact, and sense, of the thing in the large.

This may be understood best with reference to the common ability we have, to recognize a person at a long distance: long before we can make out the individual features of his face or body. Nevertheless, we can see from the gestalt or configuration of the way he stands, walks, holds himself, that it is our friend, so-and-so… The gestalt that we see contains not very much information. An artist may be able to write down four or five lines, which capture this gestalt, and it is then recognizable. This means that there is a structure, present in those half dozen lines, which, objectively, is both visible by most observers, and also does indeed reflect something that is also present, in the visual image of the person when standing nearer to us, when there is a wealth of other detail. The structure picked out, is an invariant character which appears. That is what we mean by "the wholeness" of so-and-so.

A similar thing may exist in the configurations of so-and-so's face. Once again, long before we can see the lines of his face, we see something, at a distance – and this something is enough to identify so-and-so. Again, the configuration, the wholeness is a structure which may be represented by four or five lines. Once again, it is a compact, economical structure, which underlies the persons face, and makes him recognizable.

When we speak of a shirt, or suit, or hat, or color, which suits so-and-so, what we mean is that the hat somehow continues, preserves and extends and strengthens so-and-so's face – so that he is more recognizable, with the hat on he is more himself.

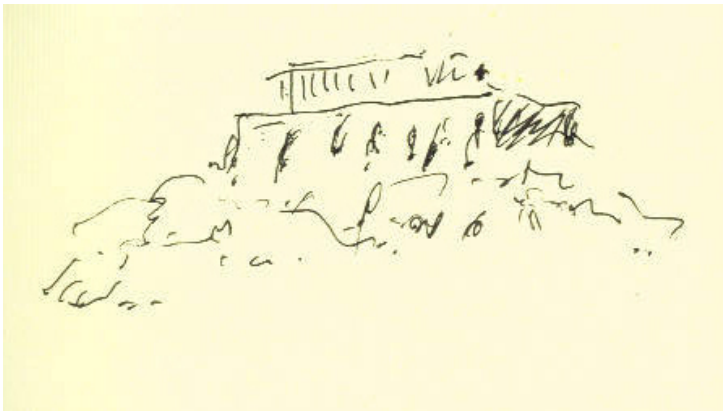
What is highly unusual, is the concept that this wholeness can be captured as a structure of nested symmetries and centers, and that each different person, with a different gestalt, is marked by a different structure of symmetries and centers. Thus, this gestalt is objectively present in the person. It represents that "something," that configuration or feeling which we perceive in so-and-so. Yet, though it is, almost certainly, the basis of intuitions and intuition perception, at the same time it is an objectively existing structure, well-defined, which may discerned and subjected to objective analysis.

It is this structure -- which exists in fields, mountains, city streets, building sites, gardens -- that is the ultimate object of all benign adaptation. It is only adaptations that form new parts that support and enhance this well-defined structure of wholeness, that may be said to contribute, successfully, to the enhancement and continued life of the whole.

Let us now return to the Parthenon. Please examine the diagrams illustrated on pages 71 and 72. These very small diagrams contain, within them, the wholeness structure of the Acropolis, at least in part.

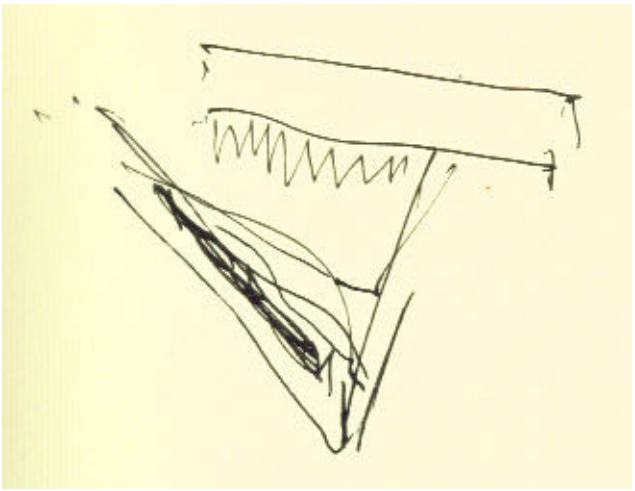
Rough sketch giving (in part) the nature of the wholeness of this site

It would have been possible, perfectly and easily possible, to build a museum which is consistent with this morphological wholeness of the site, which leaves this wholeness unharmed, and which builds on it – to further enhance the whole. Such a thing would, of course – in this particular instance – have been modest, would have done its best, above all, to leave the Parthenon as the crowning glory of the city. That would have been a profound and useful adaptation, to the present circumstance, helping the whole.



Another view of the wholeness as it is

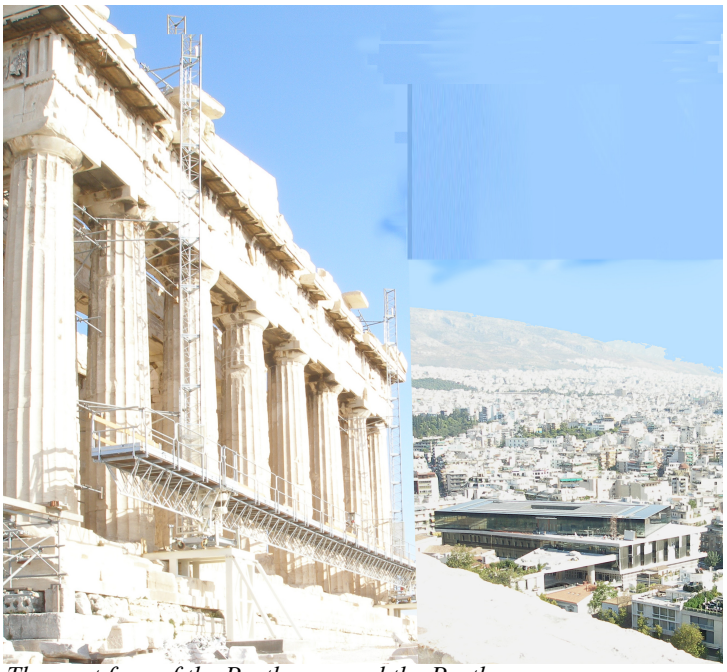
The thing that was done in the Tschumi proposal is a very different thing, quite at the other end of the continuum. It fights the structure, destroys the structure, competes with it, exhibits its disrespect. And the worst and most devastating aspect of this horrible decision, is that it was supported by well-educated, presumable wise people, by powerful people, by lovers of the arts, protectors of human civilization – who felt



The jagged structure of the new museum proposal, altogether at odds with the structure that is presently there.

that because the museum would in some fashion force the Elgin marbles back to Greece, the desecration of the Acropolis was unimportant – indeed the shocking aspect of the new museum was (possibly) part of its thrill.

What is damaged is a very subtle structure, built gradually for centruries, with enormous sensitivity, and then destroyed by present-day people who simply lack the understanding of that structure, and who could not, apparently, see the lack of connection between the image of the new museum and the beautiful place which it is supposed to respect and extend, and deepen.



The west face of the Parthenon and the Parthenon museum, as one sees them together from the Acropolis

Modern Developer Housing

The Parthenon site is a very special case, which illustrates, intuitively, what results we can expect from morphogenesis, and how blatant disregard for morphogenesis is capable, harshly and quickly, of ruining the Earth.

Now let us consider a more typical case, housing projects being built all over the world, and almost always with a similar disregard for the land. The building shown on the opposite page is part of a

housing project recently built in England. The one thing this project clearly does *not* do is to respect the land. Does it enlarge or enhance the structure that was in the land before? It does not. It is not even conceived within that kind of thinking. And so it destroys the possibility of that holiness that Casy was thinking about in the soliloquy I quoted earlier.[5]

Housing development outside Pulborough, West Sussex

Most important about this example, is that in spite of its vaguely "trad" outward style and gloss, it is *not* a product of subtle adaptations, and is therefore

nothing better than a factory product, with all the crudeness one must expect from a factory product.

The problem is, that just as in nature, good housing comes about because of hundreds of subtle adaptations, which reflect view, and light, and level, sound transmission qualities, beauty of light, unique layout of rooms to please the family or other uses, differentiation of rooms which make them truly useful, and so on. Buildings with these qualities, when carefully made, are worth a lot of money. But the pre-designed, factory-made simulacrum, does not have these subtleties, that make a place comfortable and practical – indeed far more likely everything is drawn in a drawing office, sometimes hundreds of miles from the project, and with little or no opportunity for the design process to include subtle adaptations at all. In addition, squashed together so tight, that even minimal internal adaptations are impossible, because for reasons of profit things are squashed too tight together.

Cast your mind back to the opening Hawthorne buds and flowers on pages 56-58. As the flowers open, the continuous process of adaptation keeps on going, slowly but surely, making each element fit its place in the emerging whole. It is this process, happening in five thousand centers, which creates the harmony of the flowers and the branches.

So long as a building process has this quality, the buildings and streets and gardens of a town can enhance the harmony and depth we experience in the

land. But if the buildings (or the streets, are pre-designed, and assembled under factory-like conditions, instead of by thousands of adaptations, we effectively get five thousand mistakes for every house.

Morphogenetically made buildings evolve from the direct participation of the owners, who see to it that what they build is comfortable, appropriate, and practical for *them*. No traditional owner with a direct practical and monetary pipeline to the builder, would willingly accept the arrangement shown on page 76, where the big gaping holes, are ground floor garages. Yet the wall of yawning openings you see in this picture are facing south, and are only about 100 feet from the charming river Arun. The lawn, if there was one, would be a lovely place to sit out, have a beer, let children play. But because the lawn space it is not backed by a real wall, and real windows and doors to connect with the inside, it is impractical, and the developer has hugely reduced the value of his own building, by moving too fast, and too carelessly.

Of course, he managed to sell these houses. But now the owners, two or three years after construction, are well aware that they were, in effect, tricked, or taken advantage of. The developer has walked off with the money; but too late. The houses are virtually impossible to improve, to make them habitable.

A typical house has about 2000 man-hours of labor in it. And in the course of its design and construction, it is possible (and necessary) for perhaps

five thousand elements to be sized, placed, and thought out to fit their surroundings perfectly. It is this activity, in a house, no less than in a bush, or in a meadow, that every one of these elements carefully becomes congruent and harmonious with its immediate surroundings.

In order for that house to be well adapted, all these 5000 decisions, must be just right; for thousands of years a normal process in the traditional and historical method of construction. But if these same 5000 decisions are made while the building is far from the site, on a distant drawing board, they will *inevitably* be wrong. And effectively, that means that a factory-made house, in today's world, is certain to have about 5000 mistakes in it. A few of these mistakes will have direct bearing on energy consumption, heat loss, daylight. Far more of them, will be items that have less immediate bearing on energy, but will nevertheless add to the loss of harmony in the Earth, and loss of

environment, yet in fact is not deeply adapted at all. This is why it looks slightly phony, a bit like

Recently built drawing-board houses in Pulborough

Disneyland. It doesn't look quite right. But the fact that it doesn't *look* right is not what is important about it. What is really important, is that because it is *not* created by adaptation, the five thousand decision points in these houses were not given a chance to adapt elements in the buildings, and are therefore not truly well-adapted, Instead of having 5000 points of comfort and practicality, it has 5000 mistakes, since for each point where adaptation was needed, it was ignored, and only papered over with the appearance of tradition, as a style. As a result, each of these houses has 5000 *mistakes* of adaptation. You cannot fake adaptation by visual styling and expect to succeed.

But the developer has been very clever, and has made a very good imitation. The group of buildings is made, plainly, to *seem* to be traditional, and is carefully crafted to copy traditional archetypes. In this case, traditional is certainly a catchword for developers and their buyers in the last decade or two. It is aping, or trying to appear to have, the merits of the traditional, because people to whom the "traditional" appeals will buy it.

But once again, the developers were interested in building houses that would sell. The houses probably include energy efficient measures, and take up a small footprint. But they were not built to help repair the

Earth, nor to extend the structure of wholeness of the land and its surrounding community.

In this example, this particular developer was trying really hard to persuade us that gosh, gee, golly this is almost like the real thing. *But it really is not, and if you go there and walk around, you will feel that in your bones at once*. Again, what is at issue is the wholeness structure of the place, and degree to which the houses are adapted to the deep structure of the land, *or not,* as in this case. The issue is the deep adaptation of the project, and the missing wholeness structure.

As it stands this project is a simulacrum of the real thing. It is almost worthless, because it is *not* a product of careful adaptation which is what one expects from genuine traditional buildings. This is just something which is *pretending* to be like a traditional building. But in this case the buildings do not have these special shapes because of subtle adaptations – only to try and sell them by persuading people (falsely) that it IS the real thing.

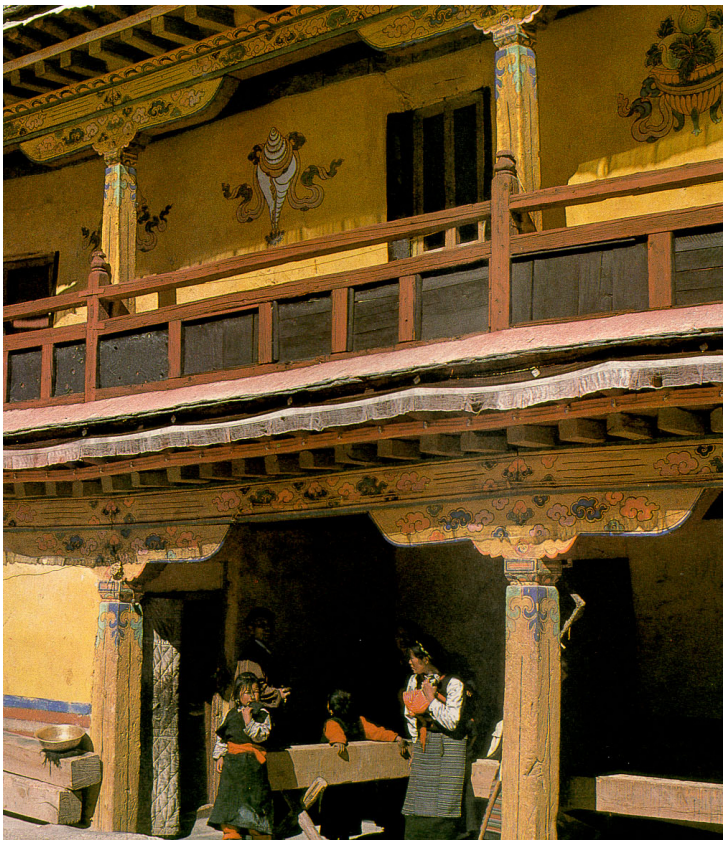
The real thing usually looks, *and is*, much messier. Let me show you what the real thing looks like. This example is less than a hundred yards from the other.

The real thing, an informal version

As you can see, this is a really different order of business. You know that it shows something very modest indeed. Not a whole bunch of money behind it necessarily. But it is, and has, the subtle, rough, gradually formed quality which makes it possible for someone who lives there to be a truly comfortable person, at one with your own life, because of the support you receive from the results of morphogenesis all around you – just, in fact, as you also do in nature.
Of course the results of this morphogenesis do not have to be messy, as in my first example. They can equally be highly formal, as in these elegant wooden buildings from Japan or Tibet. Both got their elegant shape

through morphogenesis. It could not be reached in any other way. [6]

The Shoshoin treasure house, Nara



Lhasa, Tibet: the

And, of course, there is no intrinsic reason why a building made by morphogenesis should be traditional looking. It can be any shape at all, provided that it has unfolded like a natural system, in the way that morphogenesis prescribes. Here is an example my colleagues and I built in California.

Here is an example of a house in Berkeley, built 1992.

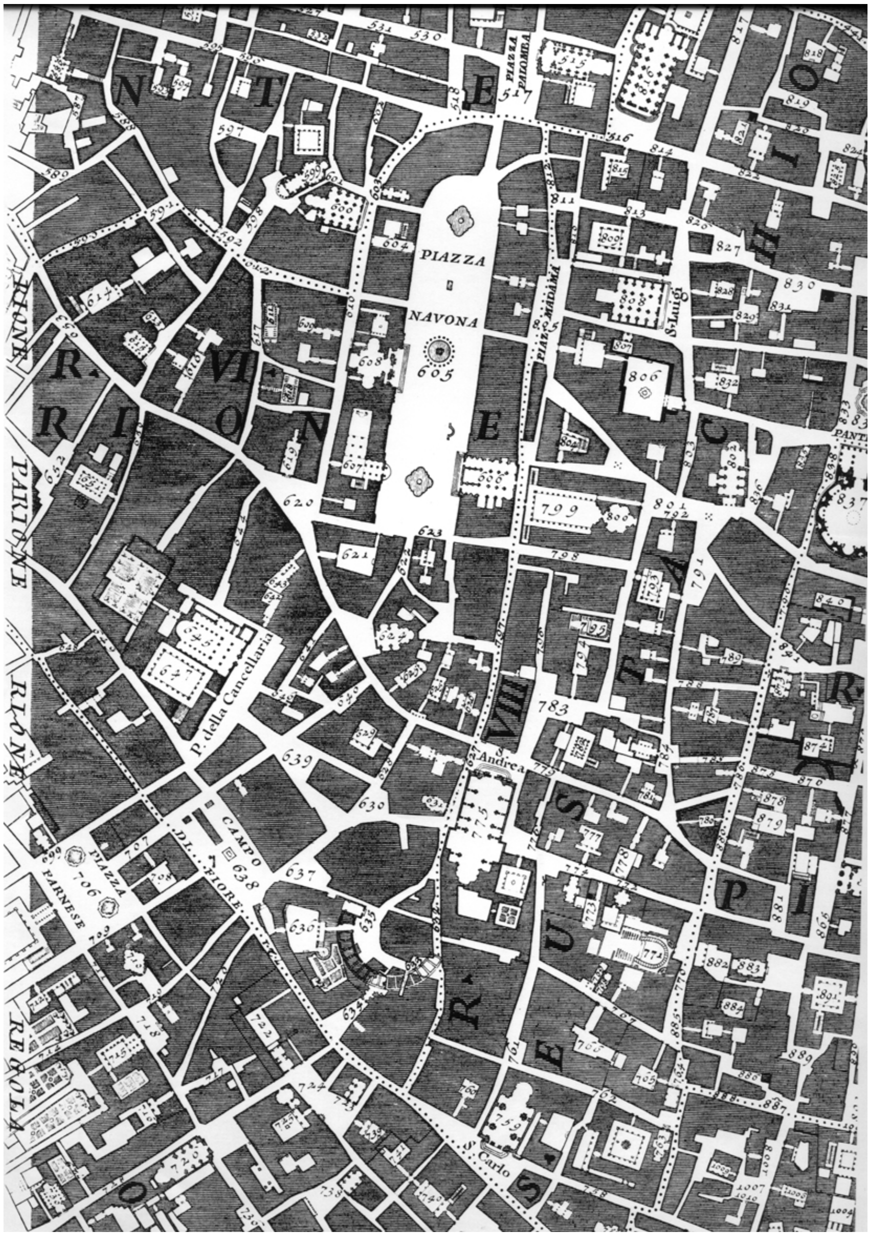
Rome as it was in mid-18th century

On the next page we see another example of "the real thing," but much larger: a physical plan of a part of Rome, as it was recorded in about 1750. Here, too, we see an almost endless tapestry of shapes, size

and angle, not willful, or made in a design to be creative, but something that arises from the process of many, many people, all paying attention, with great care, to the particular situations which exist and develop around the place where they live or work, and doing everything they can, to make the spaces habitable, beautiful, and comfortable.

All over the plan you find little bits of evidence of the subtle adaptation that had taken place over centuries. If you look at the shapes of streets, the little

Facing page: a fragment of the Nolli plan of Rome, c. 1750


PIAZZA
NAVONA
605
P. della Cancellaria
CAMPO
DI FIORE
PIAZZA
FARNESE
VIII
PARIONE
REGOLA

the little jigs and jogs and places, then a square, or a lane, then a very formal church. This widens here, and then this particular bit of street is narrower here and is wider here, and so forth. All for reasons having to do with adaptation. All having to do with that subtle creation of harmony, practical and geometric harmony, being made step-by-step, day-by-day.

If I were to take this plan to The Royal Institute of British Architects today, as a model of what kind of thing one ought to do in laying out London, I suppose they would, in their current mentality, say, "Well, this is all very nice, you know, but we are now in the 21st century and the Nolli plan was drawn almost 300 years ago. Possibly it is a kind of plan which happens to be something old that you like. But, of course, it has no relevance to our present era. This is not how we design buildings, or streets, or public buildings, or roads, or parking structures, *now*." I can just hear the ear-curling British accent as this is being said.

But the idea that this kind of morphology is irrelevant to our era is simply wrong. It all depends what you see in the drawing! If you see only a bit of history, then one might quite justifiably say that it is irrelevant. But if we see a particular, and interesting deep structure, with a highly evolved mutual adaptation between the parts, then, speaking as a scientist, it is not an *old* thing, but from a scientific point of view a *new* thing.

Its age is not what makes it interesting or important. What makes it interesting is that it is a completely different kind of structure, an important type of structure, generated differently, produced differently. The comfort that it creates is not felt because it was built a few centuries ago, but because it is simply better in its adaptation and morphology. It is a living structure, and is better adapted to human beings and their movements. Unfortunately the heritage of 20th century thinking has made us so careless that we don't recognize this structure as more profound, and also do not know (technically or procedurally) how to create this better adapted kind of structure in the context of today's society and banking institutions – what we now think of as "development" processes.

The beauty and adaptation of the Rome plan is not there merely because the growth and construction of that time were gradual. What was in place, at that time, was a morphogenetic process, which not only allowed things to go gradually so that adaptation could occur, but also guaranteed that coherent wholes would form even while this gradual, piecemeal process was going forward and allowing each place to be different and unique according to its circumstances. That is the essence of morphogenesis, and it is for this reason, that I refer, repeatedly, to morphogenesis as the core of the problem we face, in generating a living world.

VIII Morphogenesis: A New Model Of What It Means For The World To Be Sustainable

I hope that you are now beginning to see what an intensely different model morphogenesis presents to us, for our conception of a sustainable world. Even to this day, at present I do not think we yet have any satisfying, or exact definitions of what "sustainable" means. There is, of course, the very narrow definition of making sure that resources are not treated in a bad way, or in an impossible way: or the conception of zero-energy, meaning that a given building, or community, makes all the energy it needs, locally. But I don't think anyone who has thought deeply about the issues, can be satisfied with this kind of answer – not least, because it leads (I believe, inevitably) to a limited (and sometimes ugly or technocratic) way of understanding the world.

I am fairly certain that those of you who believe in ecological thinking and sustainable thinking have something in mind which is this very much deeper thing, that I am groping for in this lecture. And I am fairly certain that your reason for being interested in sustainability is because you see a vision of a world which is beautiful. That is where you are trying to get

to, whether it comes to you via the flight of egrets over a marsh, or the rolling swell of wild daffodils in a woodland, you hope for something like this in your heart. And it is this deeper and more poetic thing, that you have in all likelihood named "sustainability."

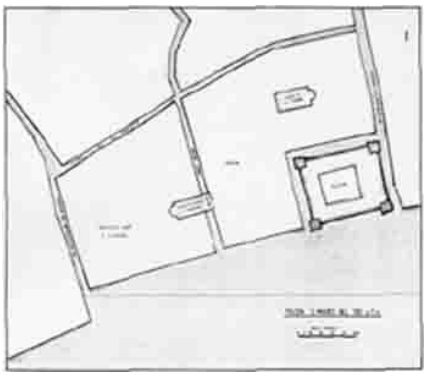
But I am not only acknowledging the inner source of your search. I am also saying to you that if you don't follow the advice of the unfolding blossoms, (pages 59, 60 and 61) and their beauty, you won't be able to have your dream. This gives us a path towards the beauty of the world. It takes *that* meaning of sustainability – that which unfolds, and makes itself beautiful, step by step, continually, and for always. This is a completely different way of thinking about building, and planning, and architecture, and ecology. It is something very clear, hard to do, and profoundly worth fighting for.

This conception is larger than the present narrow view of sustainability as a technology of resource counting. The cycle of reuse can indeed be part of a sustainable world; the cycle of attention to land, in such a way that it bears fruit, replenishes itself, can be a part of sustainable thinking. But the world must also sustain *us*, in our existence, sustain *animals*, sustain *plants*, sustain *water*, sustain *wind,* sustain *society*. The morphogenesis itself reflects, and *IS* the source of the sustenance.

IX The Morphogenesis of St Mark's Square

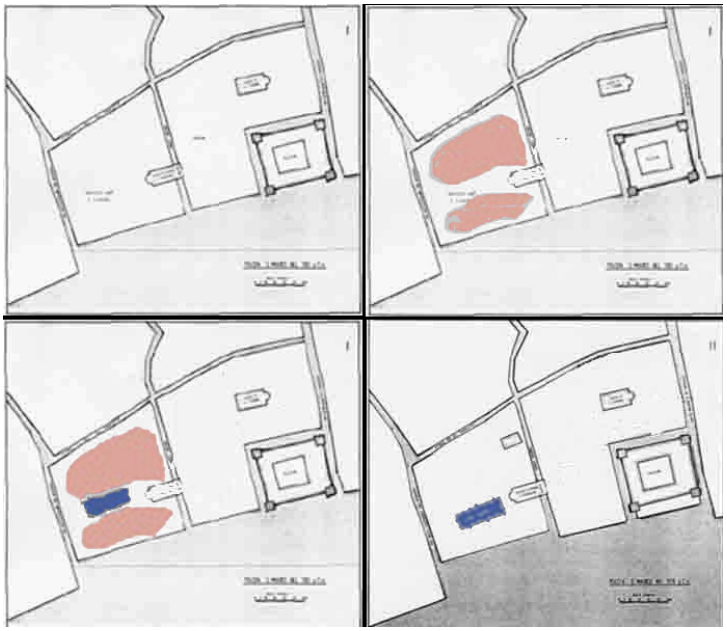
Now I want to show you an example of morphogenesis as it occurred in history, over a long time span. This is St. Mark's Square in Venice. I am going to show you a very short little movie, which is the plan of St. Mark's, roughly as it evolved about 560 AD, up till sometime in the early 17th century.[7] And it runs a bit fast so I just want to prepare you for what you're going to see. You'll see a plan of its state at some era, then you'll see a light gray cloud which is a latent figure in the configuration. And, you can feel it there. If you look at the gray cloud, you'll see that it's a product of the actual configuration of buildings and walls and so forth. Then the step after the gray cloud is a dark gray addition which is usually a building or buildings or some kind of configuration like that which came next. So first there's a perception of a latent centers, which are not realized, and then there's a point taken to make those latent centers exist. And then, we move and cycle round again.

Let's have a look: Here is a plan of part of Venice about 560 AD.



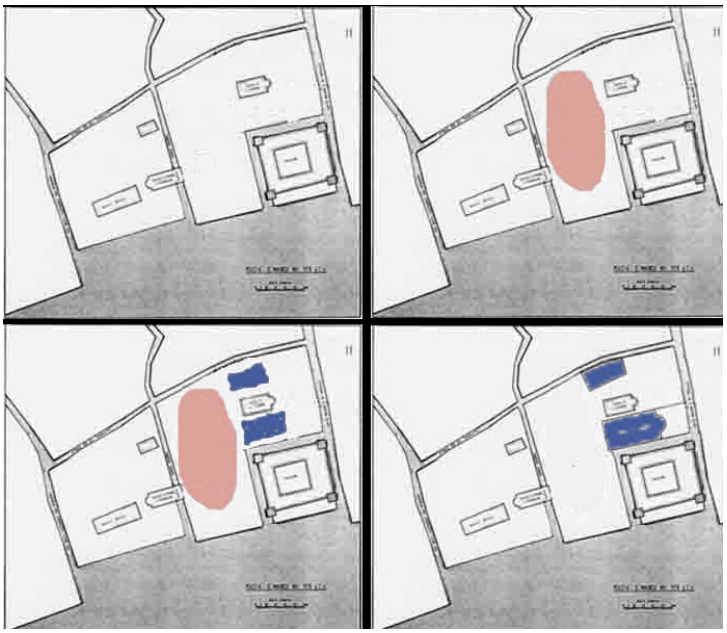
The area that later became St. Mark's square.

The sequence of drawings in the next few pages, show how this happened. The first thing that happened was that the church shown in the left hand area, was extended by another building. To explain why this was done, and how, in a simple way, I shall say, (1) that the centers painted red were defined, but not very strongly defined. Because they are weak, I call these red clouds latent centers.(2). Then a decision was taken to make these two latent centers stronger. To do this, a new building, colored blue, was proposed (3). Because of its size and position, makes the red clouds stronger as centers. This step became completed once the blue building was built. You see that in the last picture (4).



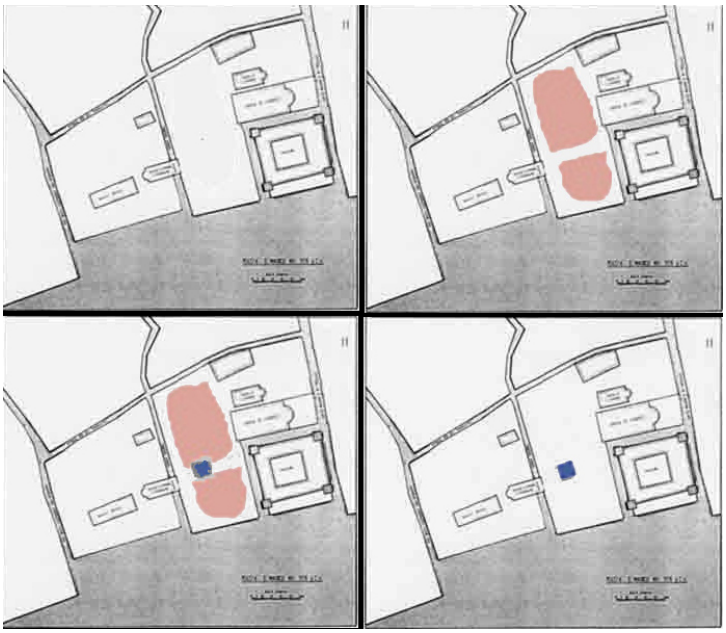
1 *2*
3 *4*

You can see what happened by reading the four in the order 1-2-3-4, left to right, top to bottom. Let's see what happened next: The next red cloud marks an area which is the original core of St. Mark's square. But this area needed to be given more definite and positive shape. So two new buildings (blue) were positioned and built in 700 AD, to have this effect on the space – as you see in the fourth picture.



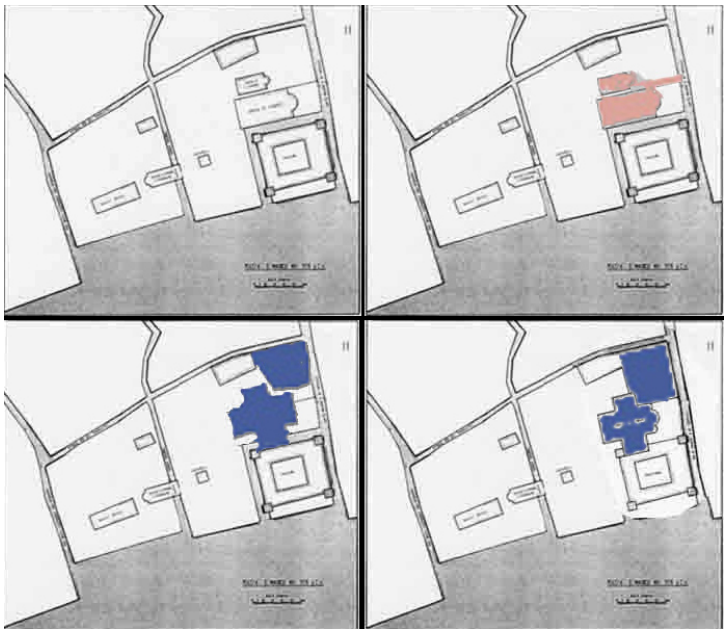
Once again, it was done in response to the earlier observation that the red latent center needed strengthening.

970 AD Round about 970 AD, the campanile was built. Again, this came about in the same way. The two red areas are the places in front of St Marks basilica, and a



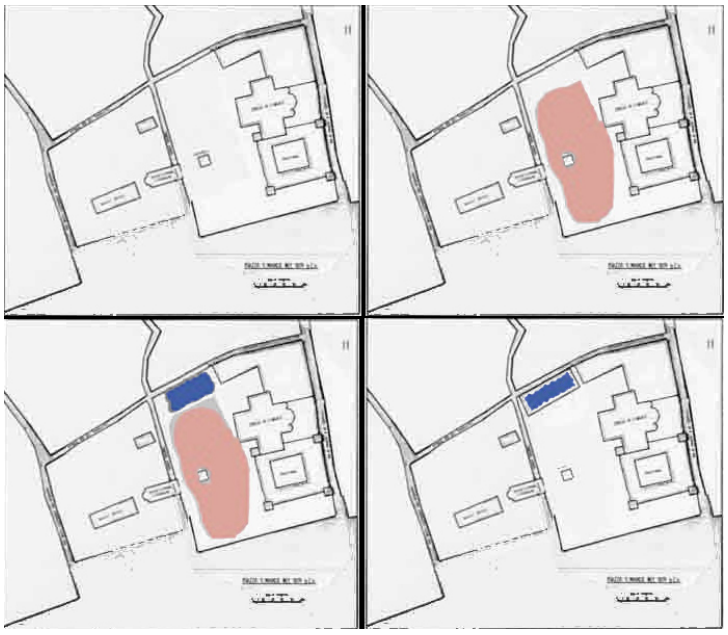
place in front of the doge's palace. The square blue dot was chosen as that point which would give most life to these two red areas, and that is the spot where the famous campanile was built in 970 AD.

1050 AD

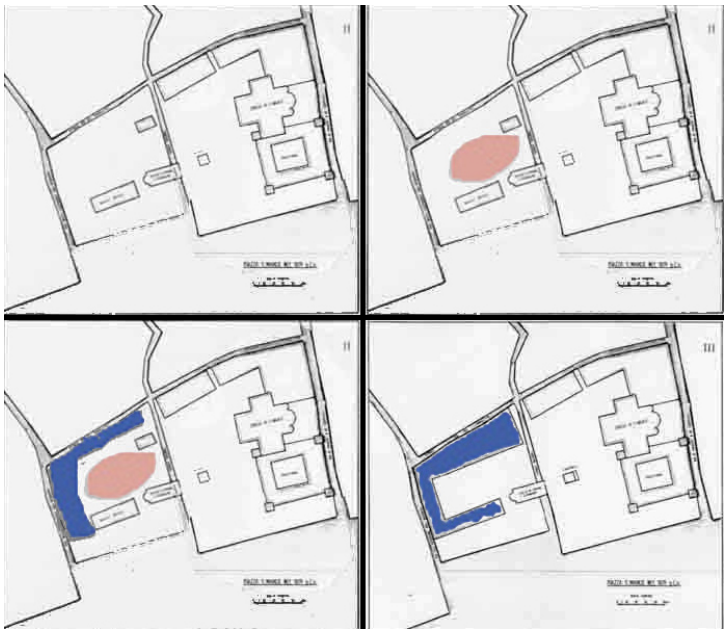


1170 AD

1270 AD



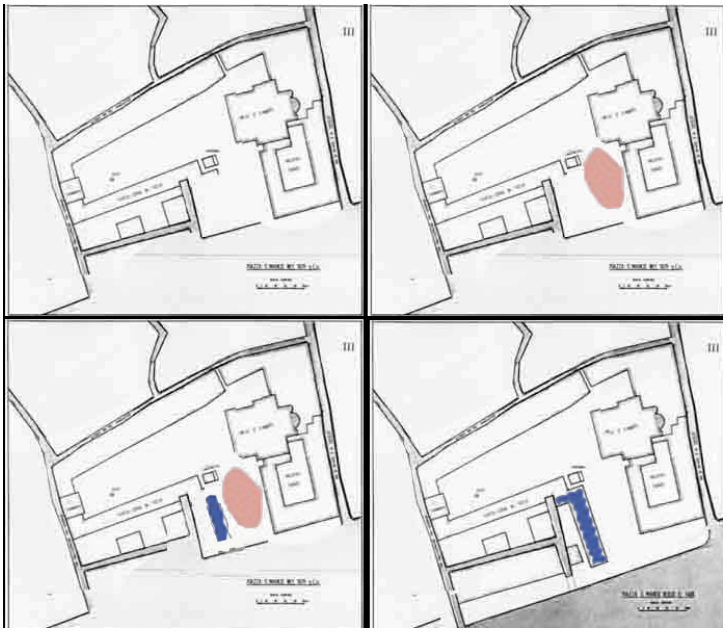
1350 AD



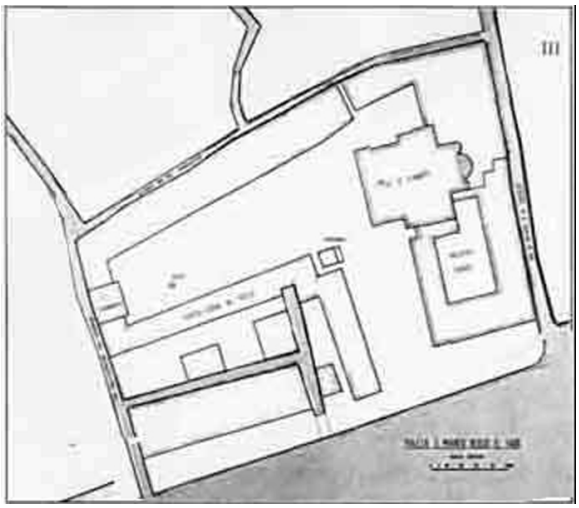
1450 AD

1500 AD

1500 AD

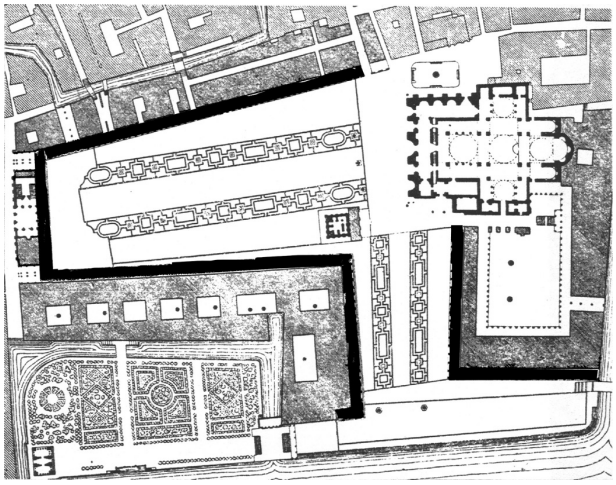


The process ends, then, round about 1600, with the configuration you see below. By this time, more or less all of St. Mark's square, as we know it, is completed.



1560 The configuration of the square in near final form

A few years later, about 1620, essentially the same configuration was a still there, but now elaborated with various details of paving, and with infill of buildings and gardens in the left over bits of space that are not visible from within the square itself.



Plan of St Marks Square, c. 1620

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Let us now recapitulate the overall format of this morphogenesis that took place over a 1000 year period in Venice. The entire process repeatedly had to do with positive space. At each cycle, the people of Venice, focused their attention on the coherence of the public space that was their common "living room." Each time people felt something needed to be done, they focused their attention on the coherence, or lack of coherence, of the public space and identified a particular place where the space particularly lacked coherence. This coherence was defined by a number of factors including the positiveness of the space, the good shape of the space, the presence of a clear well-formed boundary to

the space, the presence of an articulated center in the space, the degree of enclosure of the space, sometimes by the presence of gradients helping to make the space a center.

It is most often the introduction of a building, or buildings, which help to repair the space. In almost all the examples we have just looked at, that is what is going on. So the placing of the buildings, is used to bring the public space which the buildings define and enclose, to life.

This is one particular kind of morphogenesis, typical of the transformations that are needed in a town, or in a townscape. And this kind of morphogenesis, focusing on space, often creates a coherence, and a living character within the public realm. As a result, this morphogenesis brings with it, an intense love of life, experienced by the people in the space. It also inspires the most wonderful buildings, to help undertake the tasks of animating the space.

This quality is clearly visible in the photographs which follow:

You see, in each cycle, the pink cloud is a latent center, and it guides the formation of the next step of building. In cycle 3, the pink clouds together form a space: and the blue spot they indicate as a salient center to repair and intensify those latent centers, is what becomes the campanile. those things are done. In cycle 4, it is the later version of St. Mark's basilica itself, which gets built. In cycle 5, the whole square is

enlarged, expanded out into the Grand Canal. The sequence of ten cycles, as I have drawn them, give us a morphogenetic view of the evolution of the square as a whole, all be it in this case of over a thousand years. So this very beautiful structure that was created, was actually created by patient attention to which places have life, and how people make themselves aware of the latent centers that are there, and how these latent centers may be judged and then enhanced. Which are the latent centers that are capable of, or likely to have life? And what has to be put there to enhance that life?

The Basilica of St. Marks

Annual procession celebrating Venice in St. Marks Square

On the left we see St Mark's basilica, at the time of a festival in the square, with a plan of the square showing the state it had reached, by about 1620 AD. And what we get from all this morphogenesis is not just beautiful geometry, but coherence and *life*, beautiful life.

The people and the place. A view towards the Grand Canal

X Morphogenesis of a Window In a Texas House

I'll show you, now, another example of morphogenesis at work in architecture. It is a window: a window at the end of a dining room in a house we built in Austin, Texas. The dining room overlooks Lake Travis, and the window looks directly at the lake.

In this case, equally an example of pure morphogenesis, the centers that are the products of the morphogenesis, are the designs and sub-designs of a large and important window in a house.

To design the window, we used surveyor's tape, pinning it up, looking at it, only moving on when we felt something had improved. Here is a photograph of one stage in the evolution of the design. It is one of many steps using surveyor's tape to visualize the right window:

One of perhaps 30 or 40 steps in the use of surveyors tape to visualize the right window.

On the next pages we see diagrams of six key stages in the evolution of this surveyor's tape configuration, showing, step by step, how the unfolding actually took place, and in what order it was done.

Step 0. The empty window opening

Step 0. The sequence starts with the empty window frame, and the rough studs around the opening, marking the position, height, and width of the window.

Step 1

Step 1. The first two vertical studs, were needed to support the beam over the opening. We chose these studs to divide the window into three parts. Even this very simple step, and the placement of these two studs, creates a more beautiful center than was there, when the opening was wide open as shown in step 0.

Step 2

Step 2. Each of the three windows is now split in two, creating levels of scale, creating additional sub-symmetries, making the three centers more powerful than they were before, and paving the way for future differentiation in the separate segments.

Step 3

Step 3. The result of step 2, is mildly disconcerting. The equality of the bays and posts, slightly weakens the intensity of the center as a whole, and also weakens the divisions when they are thought of as centers. So next, the two original posts are thickened, to re-establish the levels of scale in the configuration. This has quite a dramatic effect, and the coherence of the configuration is on the rails again.

Step 4

Step 4. To create further levels of scale, horizontals are now introduced. At first three lines are made, to give good shape to the upper rectangle, and to create a thick boundary between the upper pane and the lower pane. As I remember it, the middle one of the horizontals was drawn first, but it was clear that the upper rectangle, at that stage, was not a good shape, and made the configuration awkward. So the second line (now the top line of the three) was added. This made the upper pane better, but was still not fully satisfactory. I added the lower line to make good shape in the lower large panes, and made the spacing of the three lines equal because there was no reason for them to be different.

Step 5

Step 5. Next, the middle horizontal is removed, and replaced by a flat diagonal . This gives a stronger beauty and coherence to the configuration. The entire system of panels at the top, including both the upper panes and the row of new diamond panes, make a lovely and compelling contrast to the void of the unadorned lower panels. A visible gradient coming up from the bottom, and down from the top, leads to the diamond panes as a kind of pinnacle, and enormously intensifies the centeredness of the whole window and dining room. It is noteworthy that alternating repetition has come in, in the row of diamond panes, since between the diamonds an X-shaped figure, made of four triangles, is created.

Step 6:

Step 6. Finally, still further panels are added around the lower panel of each window, to generate boundaries, levels of scale, and the void, once again. The top horizontal bar is thickened, not-separateness is increased throughout the lower part of the window, contrast becomes more intense, thus unifying the window further, the system is a highly complex mass of gradients,. inner calm is achieved by the extreme simplicity of the actions taken.

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This sequence of diagrams was made after the event, but this is the actually sequence the unfolding

followed. You can get an idea of how much more rough-and-ready the real activity is, from the photo on page 98 which shows a single stage at the time we were working it out. It is very important to understand one detailed point, which I have not so far emphasized. At each step, the search for the next step took place by careful consideration, trial and error, making intermediate mockups, *always waiting until the whole configuration got better*, and then choosing *that* one before going ahead to the next step. So each step is the product of a series of experiments which search for *the best next step*. That is the procedure being followed.

Here is the final window as we built it in Texas, and as it stands there now:

The window as completed, in the completed dining- room, after the

sequence of transformations described on pages 110 to 118

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Let us now ask ourselves once again, exactly what it means to call this sequence "*morphogenesis*." As in the case of St Mark's Square, each configuration in sequence contains centers that are latent, weak spots or undeveloped regions in the wholeness, which demand to be completed or enhanced.

And once again, the process is a *geometrical* process, it comes from the field by a process in which the uncompleted field tells the process what to do next. Of course it is possible, sometimes necessary, that this step, when taken by a human being, is taken in a state of mind which gives in to the harmony that is there, and seeks to, or knows how to, complete and extend that harmony in a harmonious way. But we must not lose sight of the fact that the same thing happens in nature, where there is no intuition acting – but the process of nature acts by operating on the deep structure of what is there. It draws the new structure from the deep structure that is there.

Above all the result, at each step, is not chiefly a matter of opinion, but concerns a judgment of what deep structure is there, and how this deep structure may best be extended. It comes from respect for what is there, and mainly that. In the case of the window I am showing, to start with, it's just a bunch of two-by-fours forming that bay window, but there's no bay window

yet. There are just openings. Then we go in with the surveyor's tape, and this short sequence of actions summarizes what kind of thing we actually did to build up a whole structure. Each step comes from the previous step by a kind of morphological improvement. Here again, as in the St. Mark's example, the form created, has been grown, step by step, at each step what is grown next comes from what happened just before.

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Once again, this is almost pure morphogenesis. Each step allows one new elaboration of structure. At each step, new centers are born, and are chosen and shaped, and given certain deliberate geometric properties, in such a way that the newly created centers sustain, and support the wholeness of the room, and of the view: making it a fitting window for the dining table, and a beautiful place to eat.

The window seen from outside

XI A Universal Process for Creating Centers

The morphogenesis which created St. Mark's Square, and the morphogenetic process which created the window on Lake Travis in Texas, are both center-creating processes. In the St. Mark's process, each cycle described on pages xxx-xxx, identifies a center which is latent in the urban landscape, then builds a new center, with its accompanying system of centers, which then spawns some new centers which are latent, and in good time then fuels the elaboration of that newly spawned, latent center.

In the evolving window, the centers which appear, and which become strengthened, are mainly rectangular domains, plus a few that are shaped by triangles, within the overall window frame. As these centers get strengthened, by thickening of boundaries, by insertion of ornaments like the diamonds, or the thin slivers that form boundaries to the larger rectangles, all in all choosing the centers that are introduced in such a way that the previously existing centers become more coherent.

These two examples or morphogenesis are typical, not unusual. All known forms of morphogenesis are, in one fashion or another, systems of center-creation. Whether these centers are cells in an organism, structures of proto-bone, whirlpools in a

weather system, or ripples in a stream, all of them, without exception, have their origin in some process of center creation. Indeed , the very essence of morphogenesis is that it is a process which endlessly creates centers, and by so doing, creates geometrical and living form. Morphogenesis is a continuous center-creating process.

To understand the nature of morphogenesis, we need to understand its recursive character. That means that each step creates or strengthens some one center, or several centers. But to be a center, this center is itself made of other centers – inside it, surrounding it, and overlapping it. So there is a only one process: but this process must be applied to every part of every part, to make an infinite variety of centers, each having specific, and various, characteristics, but each one sharing the property of being a living center.

Here is a very simple description of this recursive process.

1. Determine the focal point of what is to become the next living center.
2. Make a boundary which is the outer boundary of the place which is to focus on this focal point.
3. Thicken this boundary, and make it up from smaller coherent ornamented centers, thickened, and significant in their own right .

4. Inside the boundary, shape the main center, a large zone and space which is supremely "positive" in shape and character .
5. There is a gate or entrance to this place.
6. Create a gradient which leads from the entrance point towards the focal point.
7. Shape the focal point as positive space.
8. Around the focal point put detailed centers of a touching quality. This means, introduce the structure of not-separateness into what you have done.
9. Against the touching quality, put a stark simplicity and plainness that sets it off.
10. Off-beat, syncopated to the stark simplicity, there is an even smaller center, lost, protected by layers. This is also stark and quiet. It is reminiscent of the void.

NOTE: In repeating the ten steps, it will be necessary to leave out steps occasionally, and to clean up the configuration to simplify stuff that gets too cluttered. This still needs to be systematized.

SECOND NOTE: In applying this recursive process, all fifteen properties come into play.

Now apply the same ten-step sequence recursively, to any of the emerging centers which have appeared in the configuration. The choice of which center to embellish first is left to you, but should probably be

the center which shows most promise of animating the center as a whole.

FURTHER NOTES: THE STRUCTURE OF EVERY LIVING CENTER

1. The outer shell is a boundary where the center meets the world beyond.
2. Inside the outer boundary, is a wider, deeper boundary zone. This protects the main center.
3. The main center is entered by a passage which connects the outer to the inner. This is a gate. There may be more than one gate.
4. As one passes through the main center, there is a gradient toward a smaller, finer center. This gradient focuses attention, life, towards some still smaller center, which gives focus to the whole.
5. The smallest, focused center, is more elaborate, stands alone, offers opportunity for contemplation and quiet. But it is not the smallest, or the most focused place.
6. Standing apart, in contrast to the smallest center, there is an even smaller center. This gives the whole its zest.

FINAL NOTE *This process can be applied to all centers, large or small, and of virtually every type.*

- The process applies to a kitchen.
- It applies to an armchair or a table.
- It applies to a neighborhood.
- It applies to the downtown of city.

- It applies to a lake and its ecology.
- It applies to a single room.
- It applies to a monastery.
- It applies to a house.
- It applies to a garden.
- It applies to a jug that has been filled with flowers.

This summary contains the essence of what is happening in morphogenesis. The process spawns an infinite number of living centers, all interdependent, co-extensive in space, linked laterally, and each giving rise to further millions of differentiated smaller centers.

XII Another Way Of Thinking About The Fifteen Properties.

Extensive research has shown that coherent geometry arises from morphogenesis, because of deep-seated causal links linking coherent centers.[8] To some degree each center gets its coherence from other centers with which it is associated, and it is this cooperative helping which generates more and more coherence. Otherwise stated, each center is (recursively) dependent on other coherent centers for its own coherence. Its

coherence arises because of its relationships with other coherent centers. To understand this idea, it is helpful to regard a center as a physical manifestation of coherence in space, and to define a center in this way, as a primitive: Definition: *A center is a zone of coherence that occurs in space. That is all one can say. There is no other more elementary substance from which centers are manufactured. Centers can only be manufactured from other centers.*

A center may arise, initially, as a minor non-homogeneity in space. Thus, a speck of dust in a vacuum might be such an non-homogeneity; or a line in space which is different from all that surrounds it is an non-homogeneity; indeed any zone which is internally homogeneous in material, and surrounded by different material, would qualify as a non-homogeneity. These are configurations which act as seeds to morphogenesis.

Morphogenesis then occurs by the repeated application of fifteen operators to the centers in the configuration.[9] These correspond to the fifteen properties identified in *The Nature of Order*.[10] I call them *operators*, here, not properties, because each one is expressed as an instruction which can be applied to a configuration, then giving a concrete geometric result. Each operator can be applied to any of the centers in a given configuration, and can thus transform the configuration in a large number of different ways. The fifteen operators are listed below.

1. The **CONTRAST** operator. The coherence of this proto-center, is enhanced by contrast, whether of color, or material, or gradient, or density. The contrast operator increases the contrast between the inside and the outside of the center, to make the center stronger.

2. The **STRONG-CENTER** operator. This is a generic operator which simply makes the coherence of a center stronger, by making it more "center-like". It does so by calling any of the following operators: The Thick boundary, the Levels of scale operator, the Gradient operator, and others. This needs work!

3. The **THICK-BOUNDARY** operator. This operator places a thick boundary around or partly around the zone occupied by a weak center, thus making the center more coherent. The radial thickness of the boundary is large, sometimes of the same order of magnitude as the diameter of the original center being surrounded. It is large enough, anyway, so that second level centers can populate this boundary, meaning that the thickness is at least one quarter the diameter of the original center.

4. The **LEVELS-OF-SCALE** operator. This operator modifies the given center, by embellishing it with smaller centers. These smaller centers are typically one half to one third the diameter of the original center, but sometimes smaller. They may be created within the original center, or in the space adjacent to it.

5. The **ALTERNATING-REPETITION** operator. This operator repeats centers to form an array. This may

happen in one, or two, or three dimensions. The key effect of the operator is that it then creates a second system of centers between the loose packing of the first centers, in such a way that the first centers and the second centers are made strongly distinct, by shape or material or color, and become more coherent, by virtue of the alternation. In the course of the operation, the operator often changes the shape of the first centers, to make the in-between, second centers well shaped.

6. The **LOCAL-SYMMETRY** operator. This operator strengthens a given center by introducing one or more local symmetries – most often a bilateral symmetry. If the center already has a natural axis of orientation, the symmetry is made to coincide with it. Otherwise, it orients the symmetry to make it as congruent as possible, with the field induced by other nearby centers (i.e. where it seems natural). It is best to put the symmetry on a center that is already *nearly* symmetrical.

7. The **POSITIVE-SPACE** operator. This operator is one of the most important, but hardest to define. It is to be applied to any center, and helps to shape the so-called 'empty' space in the center. The positiveness of space comes from a combination of good shape, local symmetries, boundedness and above all from the appropriateness of the space for human purposes. This operator is applied most typically to the latent centers formed in the space between other centers, to give this space form.`

8. The **ROUGHNESS** operator. In the course of unfolding, as the operators push and shove, to make various things happen, as required by the operators, it happens, very often, that something does not quite fit neatly. Instead of creating a perfect, or pristine shape, it is then necessary -- absolutely necessary -- to relax certain conditions, in order to make the configuration work successfully. For example, a putative rectangular building, when put on a difficult site, may need one corner. to be off 90 degrees– simply because of a tree that is in the way. In another instance, a doorway may need to be crowded under a roof, requiring the doorframe (and its door) to have one of the upper corners cut off, so that the door can be put there *at all*. For a similar reason, one wall in an exterior envelope of a building may need to be gently curved, and if left straight will fail to adapt itself to some important geometric feature of the site.

In all these cases, the roughness that is introduced, is created of necessity, because some aspect of the building fitness for the site is more important than a perfectionist desire for regularity. So this operator gives the unfolding process permission to be rough and ready, when this serves a larger, and really important aspect of an ongoing adaptation.

9. The **GRADIENT** operator. This operator creates gradients that point towards or away from a given center. The common gradients are gradients of size, gradients of contrast, gradients of spacing, gradients of

orientation. The gradients are implemented through smaller centers that have the above-mentioned characteristics, varying with position in the parent center.

10. The **DEEP-INTERLOCK AND AMBIGUITY** operator. This operator is used at an interface between two adjacent centers. Its purpose is to create a zone, usually an ambiguous zone, forming a third center between the two original centers. It is made ambiguous, in the sense that there are ties from one side, `and ties from the other, with the result that there is a visible` ambiguity about which of the two outer centers this new center belongs to.

Since the belonging of the third center, to the two centers adjacent to it, is ambiguous, this is often accomplished by mutually interlocking "peninsulas," which penetrate the ambiguous zone, first from one side, then from the other side, thus creating an interlocking configuration.

11. The **ECHOES** operator. This operator has mainly to do with angles and curves and ratios. As the collection of centers grows, there will be a certain predominant angles, or curves, or ratios or proportions in the shapes that have been created. This operator, then uses the statistics of the angles that so far dominate the configuration, and introduces these angles (or curves or ratios) as a default in the drawing of later centers that are created, thus slowly giving the whole

system of centers a family resemblance shared by many of them.

12. The **GOOD-SHAPE** operator. This operator directly influences shape. If a rough outline of a shape has been generated, this operator examines the overall convex pieces of the shape, and tries, as far as possible, to strengthen or emphasize these pieces, within the segments of the curved boundary, in such a way that makes the overall shape more distinct.

13. The **INNER-CALM** operator. This operator is a clean-up tool working along the lines of Occam's razor. It simplifies a configuration. It removes, as far as possible, all superfluous structure. I am not yet sure how to state this in operator form; it's a bit of a puzzle.

14. The **VOID** operator. This is a pervasive operator, working at many levels of scale. The basic idea of the operator, is that at the core of a center, there is always some undisturbed and perfectly peaceful area which lacks busy-ness or excessive structure. It is very important that each serious center, has, within its boundary, some area like this. Often this area is large in extent, compared with all the other elements that have a great del of structure. This operator can be expressed arithmetically, as a statistic on the whole configuration.

15. The **NOT-SEPARATENESS** operator. This operator comes into play after the majority of centers have been established. The purpose is to overcome any separation that is caused between the configuration and its environment, or between any individual center, and

its immediate environment. To mobilize this operator, wherever a boundary is too sharp, bridges should be formed, by chains of centers, which cross that boundary, thus creating a softer and more permeable edge. In successful applications of the operator, the chains of centers which it generates sometimes have considerable length, and are anchored in the space on either side of the original 'hard' edge by gradients of size, color, contrast, or other variables that vary with distance from the edge.

XIII The Direction Of The Adaptations: How The System Knows Which Way To Go

The crux of the process described in the last sections hinges, of course, on the ability to see and judge what is the wholeness, and what preserves the deep structure of the wholeness. Which among various possible "moves" in an unfolding process, does the most to extend and preserve the structure?

There is, fortunately, an empirical answer to this question. Many years ago, while working with my graduate students I made a simple, yet highly surprising, discovery. I was teaching my students to get a feel for the process I have been describing in this lecture. The crucial question, that one always comes down to, is "How can you compare two things to determine whether one is more profound than the other, or more "wholeness-preserving?"

At the time, we were already working on the fifteen properties described in *The Nature of Order*. These fifteen properties are not so difficult to elucidate. But it is more difficult to say "Well how do you know for sure which of two vases, or which of these two tables, or which of these two entrances, which of the two, A or B, is more profound, more harmonious?"

How do you make that judgment? And, above all, how can one do it so there's agreement among people, and not just a lot of people squabbling about their private opinions?[11]

I found out that there was a series of questions that could be asked, which were rather strange. Essentially something along the lines of "Okay, you've got in front of you, two possible moves, two possibilities, let's call them A and B. So you've got your A and you've got your B that you're comparing. Now, tell me, which of A and B is more like a picture of your own soul?" I would always hasten to add, to the person being asked this question "It is not necessary to believe any religious interpretation of the word "soul," to answer this question. It doesn't matter whether you believe in such a thing as a soul. This is completely irrelevant, as long as you are willing to take the question seriously, and ask yourself whether you can make a judgment (even if it seems like nonsense) deciding which of the two is more like a picture of your own "soul."

And there are various other ways of asking that question.[12] You can ask things like which of the two is more healing, which has more life, or which one has the greater effect on your own wholeness. There are a number of slightly different questions like that, all slightly different, but all with the same essential core to them. The one that asks which of the two is more like a picture of your own soul, although it is an abstruse

version, (and in terms of academic thinking during the 1980's it was certainly the one which sounded most outrageous) is the one which I find most useful, and most reliable empirically. I have put this forward as a new kind of empirical measurement. This measurement does not (for the moment) ask whether the soul is real, but it simply gives you access to structural information about A and B, which you cannot easily get any other way.

What makes this type of measurement important, is that when people do it, and make judgments in that way, comparing A and B, and B and C, and so on, it turns out that they agree, to an extraordinary extent. Like other experiments the results are somewhat statistical, but on a given comparison, typically four out of five will agree. And then, having made the judgment that way, then gradually they begin to realize that the A, or the one they have chosen by this criterion, is having a more profound effect on them than B and C and D.

But if you then begin to isolate the things that are high in those dimensions*, it turns out that they will be the ones that are produced by a more pure morphogenetic process*. In other words, all that is happening to reach that kind of result, is that the thing takes the world, takes it's wholeness, transforms that wholeness somehow to extend that wholeness and enlarge it. And so these are the very things, then, which are viewed as having spirit.

I know this is a dreadfully collapsed summary, but I hope you can see the significance of what I am saying. Because if (as I am telling you) it is an **EMPIRICAL** result that enables you to use this kind of measurement to go forward in an unfolding process, and it enables you choose the best "next step", each time the process continues, why then you can say "Well, naturally, this is what we want to do for the land (or the building, or the doorway, or whatever), whenever we can, to move it forwards in that direction."

That is more on the morphogenetic level of permitting these subtle adaptations that I was illustrating in one or two of the pictures. And so in terms of actually uniting the thing, although its not right to call it a thing really. But anyway, the living organism that is a town, or a building, or whatever, becomes closer and closer to us the more that process goes forward. So then we are satisfied, we are enlarged, we are made well. We are at home.

So this connection between morphogenesis and the question of the spirit in things (actually the embodiment of soul), in things, places, organization of land. This is a real empirical connection which we can rely upon.

XIV The Emergence of Coherence And Geometry

How does a process of morphogenesis "know" how to take the next step, when placing new centers?

The nature of this positive "direction" for a living system – the direction that takes the system towards a more harmonious state while the wholeness is preserved, extended, and enhanced, may also be described in another way, which relies on the sequence of steps that are needed to get to it. This is the main argument of Book 2 of *The Nature of Order*, *The Process of Creating Life*, and is discussed extensively throughout that book.[13]

The idea of wholeness-preserving transformations is clearly visible in the unfolding of St Mark's Square (page 23 of this essay); and visible, also in the morphogenetic unfolding of the window in Texas (page 27). In each case, the process goes cyclically, through a process of discovering the latent centers in the system, then taking a next step which enhances the configuration of centers in the wholeness, thus proceeding to a deeper wholeness, consistent with the earlier wholeness.

What we experience after the fact as geometric harmony in a system, is precisely the fact that such a sequence of self-consistent wholeness-preserving steps has occurred, and that we can see the trace of such a

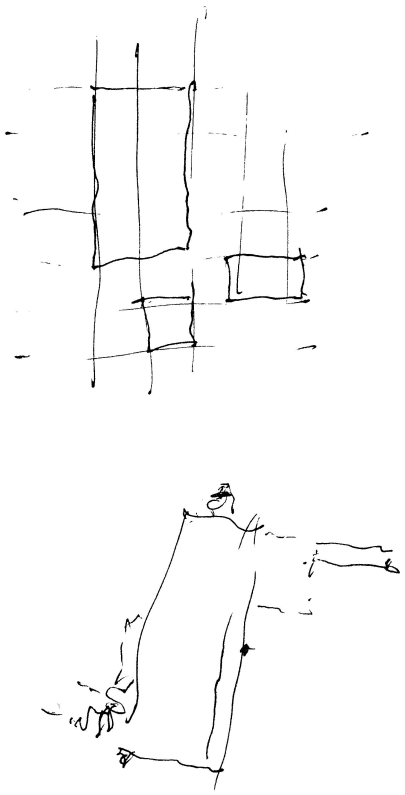
self-consistent sequence of transformations in the geometry.

But the forms resulting from a morphogenetic process also carry a characteristic *signature*, in their purely geometrical aspects. To understand this geometric signature, consider the following. The geometries of St. Mark's Square, and of the Gioja window in Texas, though enormously different in scale and purpose, are similar in a number of important ways. Both, viewed as structures, are more granular, have many levels of structure, more than we were used to in the technical products of 20th century architecture. They are not aligned so rigidly to a Cartesian grid as contemporary buildings usually are. They are not modular in the precise arithmetic sense of equal and identical components stacked up alongside one another. Both contain minor irregularities where needed, to make everything come out right.

But they are not *highly* irregular. Neither are they "organic" or "funky" in the deliberately unorganized geometric manner espoused by certain contemporary artists and architects who seek something spiritual, or something resembling nature. Buildings are, after all, buildings; there are profound reasons for the appearance of nearly straight lines and planes, there are good reasons for windows and doors which are roughly planar, corners which are roughly right angles, and so forth. The apparent organic, rambling form of

order, seeks justification in arguments about biology – but these are shallow arguments.

The geometry of my two examples, is very general. In the case of a built world that arises through morphogenesis, it is a geometry which is largely straight, but sometimes (more rarely) curved. It is a geometry which often has rough right angles (once again for compelling reasons), but it sometimes contains varying acute and obtuse angles. It includes repetition of elements and spacing, but the repetition is rarely perfect, and the elements are distinguished according to their unique contexts. All in all, the geometry has a subtle, friendly, kind of organization, which contains symmetries, and rough equality of spacing, but simultaneously contains gradients, echoes, and variation which follows from the situation and the context. A very much more complete account of this geometric signature is given in Book 1 of *The Nature of Order*, especially in chapters 5 and 6.[14]



The upper picture is a cartoon of the mindset which has generated most of the buildings of the last one hundred years. The lower building shows the morphology, and geometry, which typically appear as a result of morphogenesis, in the case of architecture

The upper picture shows the alienated, rigorous, straight-jacketed form of many contemporary buildings, and illustrates, also, the mindset which accompanies these buildings.

The lower picture shows the typical results of morphogenesis and unfolding, when it is happening in the world of buildings. In a recent seminar at Cawdor castle, in Scotland, I drew these two pictures when asked to describe the difference between the absence of love and the presence of love. This kind of geometry is, oddly, a kind of morphology which though known in many traditional cultures, has never yet been explicitly identified, nor espoused, by architects, as the right way for the forms of building to come out. It permits magnificent symmetries, and centers; yet it is supplemented by irregularities, throughout the fabric, that are always necessarily present to make the adaptation work. It is governed by the principle that centers are to become living, and shaped in any way that brings them life.

Thus this particular geometric character, or signature, which I describe as a necessary result of morphogenesis at work, is the easiest way to judge the character of landscape and building, the quickest way to make a first judgment whether the morphology will protect and complement the Earth. It takes some practice and experimentation to become aware of the subtleties of the step by step process, and careful

judgments, but you can achieve the signature better and better as your skills develop over time.

XV How the Vital Systems of Sustainability Depend on Morphogenesis (*this chapter is so far in very rough draft form*)

On pages 7-13, at the beginning of this book, I listed a number of major concerns, or issues, which have been considered the backbone of a sustainable future. In the last two decades, these issues have been discussed mainly in isolation. I shall now describe the way I believe these issues are themselves dependent on morphogenesis. If I am right about it, it will follow that the program of achieving a new Earth, in which the Earth sustains itself continuously, is likely to work well, only if combined with a large scale revision of policy to implement a spreading program of morphogenesis throughout the warp and weft of our social system, and its planning, building, and construction methods.

Let me observe, first of all, that all the programs listed, whether concerned with energy resources, mineral resources, water resources, agriculture, or human population, animal and insect populations, and plant populations, are broadly similar *in their essence*. All of them attempt to conserve resources, and to create conditions where water, air, animal life, plant life have sufficient resources to meet

needs, and are intended to be set in motion in such a way that encourages them to interact *cooperatively* – in other words, so that the way each program works helps the maintenance of resources in the other programs, both locally and globally, all over the Earth.

There is, then, a dynamic wholeness which we must aspire to, and attempt to foster, in the environment and in our social systems so that this wholeness keeps itself alive.

What exactly does this mean? It means that each subsystem, indeed every component, of the environment and social system, must be maintaining itself in a healthy state, and that each also helps the other neighboring systems to be healthy.

This is rather different from the technical solutions that have been offered in the first wave of sustainability efforts. For example, the solar panel is intended to be a system which receives solar energy, and converts it into electrical energy or heat energy (depending on the type of solar panel we are talking about -- selenium cells or black tubes heating water). Of course this is a good thing. It takes what appears to be a free energy resource, and puts it to good use.

But this solar panel system exists essentially in isolation. It is not helping other systems, and other systems are not greatly helping it. It would be better, for instance, if the solar panel were conceived and made as a roofing system, and capable of allowing piecemeal, geometric adaptation in the roof. This is technically

feasible, but it is not the direction of solar panel design at present. Rather the solar panel is considered in isolation, and optimized for the most efficient way of converting solar energy into heat. The devices resulting from mass production, then tend to be made in rigid shapes that cannot possibly fit well into a complex system of roofs following from the plan of a morphogenetically conceived building. So the kinds of subtleties in plan that typically arise when the plan is genuinely adapted to its environment, and to the disposition of well shaped rooms, are over-ridden by the crudeness of the production process.

If our building methods and processes are to achieve the profound results that are hoped for and expected, the underlying strategy will have to recognize that the Earth's surface must become a system that is in continuous homeostasis. It must take care of itself in such a way that all the systems, large and small, subsystems and sub-subsystems, are linked to themselves and to one another so that they help each other. That will depend on a vision of the Earth as constantly evolving, yet constantly, in some fashion monitoring its own resources of all types, in such a way as to make every part locally stable, even while it is evolving, changing, and adapting to changing circumstances in the world around it.

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This goal, can only be achieved if we create a mental and procedural framework in society which is based on the idea of *continuous*, *ubiquitous*, *repair*.[15] And this repair is necessarily physical, though it will also have associated non-physical components.

In most parts of nature, we find systems which, (provided they do not go outside certain parameters), are both capable of repair and are for the most part self-repairing. In an organism, every move that is made, is made in such a way that the changes or structure created, repair the structure that is there already. This is what we need to emulate, if our world is to come back to order.

To a very small degree such an attitude is present in human society, and in our view of the environment – but not even remotely to the degree required.

It is now time to see how this necessary interconnection of subsystems in a sustainable world, must be related to morphogenesis. Let me repeat what I take to be the core principles of adaptive morphogenesis.

. . . missing text . . .

Bearing these principles in mind, let us consider some examples of sustainable issues where we can examine the intertwining of technical sustainability and morphogenesis.

1. Care of Bioregions

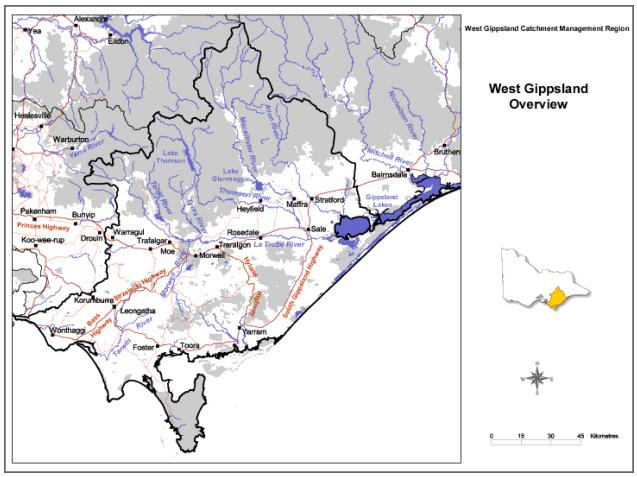
There is growing interest in the importance of bioregions. A bioregion is usually defined as a naturally occurring, relatively self-contained region, in which a watershed catch basin, naturally occurring wild species of plants and animals and insects, relative homogeneity of local climate, define a bounded geographic area, and permit the system in this boundary to benefit from keeping flows of energy, food, building materials, money, transport, and natural water and roads, as far as possible, internal to the area, so that the system can be – at least to some partial extent – be considered independent.

This concept is not yet fully well-defined, but it has wide appeal in sustainability circles. Is it linked to morphogenesis, and if so, how?

From Wikipedia :World Wildlife Fund's full definition of an ecoregion, is widely accepted and used, is the following:

> *A large area of land or water that contains a geographically distinct assemblage of natural communities that*
> *(a) share a large majority of their species and ecological dynamics;*
> *(b) share similar environmental conditions, and;*

(c) interact ecologically in ways that are critical for their long-term persistence.
--World Wildlife Fund - Ecoregions



West Gippsland Bioregion, Australia

West Gippsland Forest

This is a classic problem of decomposing a complex system with internal flows of many kinds. If the system has to be divided into workable regions, should they follow traditional political lines; or is there a better argument for using a subsystem analysis. Would a program of this kind be helped by a widespread program of morphogenesis? Conversely,

would a program of morphogenesis be helped by the creation and support of bio-regions?

A widespread program of morphogenesis, applied to a land, will identify and respect the internally coherent regions which are defined by watersheds, rainfall, tributaries, and natural irrigation of land. Morphogenesis chooses this, not because it is especially concerned with water or economics as such, but because the structure of water in a region, its flow, storage, and conservation, the land, is a natural part of the global structure of the regional system. A rule of development which protects and enhances the natural flow of water as a necessary part of morphogenesis, will therefore support, and lead towards the goal of sustaining bioregions.

2. Green Building Materials

The idea of green building materials originated by a combination of two desires: (1) to use materials whose production and transportation would have a low energy cost, and (2) to make it possible top use materials that are local to a region, primarily. …. is intended to promote materials which are low in energy cost during production, which do not have to be transported over long distances, which come from

renewable vegetable or mineral resources, and which have low cost and high insulation values.

There is a general US-wide and World-wide index of green materials. This approach fails to take into account the different economic conditions of different households, the importance of building in conformity with the materials available in a given bio-region.

This is congruent with the principle that materials used on a building site should as far as possible reflect the materials of the local surroundings, both those in the other nearby buildings, and those in the mineral and vegetable deposits available nearby, not merely for economic reasons, but because these will be most harmonious with the land. This principle, arising directly from the practice of morphogenesis, will stimulate precisely the agenda that green materials emphasizes, except that it gives the principle a more positive and less arbitrary quality, because it emerges from the land itself.[16]

Further, the most fundamental aspect of building materials, from the point of view of morphogenesis, is that the various parts of any thing being built, allow themselves to be modified, shaped and adapted according to its local needs, themselves dependent on its context in the building, and the detailed wishes of the users. All these needs are reflected in easily workable materials, and fail to be reflected in the high

tech components that are either inherently hard to work, or not manufactured in easily workable versions, that are expensive to modify, and tend to overwhelm a configuration by their intractability.[17]

An example of a community which is 90 efficient in terms of its local energy production, is the small town of Gruessing, in lower Austria, not far from Vienna.[18]

3. Practical Steps Towards Protection of Natural Ecology

Detailed explanation of the large scale management of ecological regions has been given by Stuart Cowan. His most ambitious and comprehensive model is the Conservation Economy, in which the patterns and features of a self-sustaining economy regional ecology are spelled out, in an implementable form.[19] The central purpose of this program is to

4. Self-Sustaining Local Economies

Many experiments around the world are making efforts to regenerate local economies. Myanmar (Burma) made such efforts starting in the late 1980s by trying to reduce flows of cash and information across its borders. Later a repressive military government imprisoned Aung San Suu Kyi who had championed

this effort, and Myanmar entered a mixed economy, which still benefits from the effort to keep the cycle of money flow internal to the country.[20]

Aung San Suu Kyi

The Myanmar experiment in a closed economy, allowed money to flourish and benefit the region, and its industry, instead of losing the proceeds of industry to be bled off by international corporations, thus stunting the region's economic strength.

This is one of the most important principles: that a region, neighborhood, indeed any viable center, should maintain a larger proportion of flows internal, and only a relatively smaller number crossing the external boundary.

In somewhat similar fashion, the town of Gaviotas in Colombia took 30 years to regenerate its natural environment, and then discovered they could

participate in the global economy using their natural resources.[21] The Grameen bank has made thousands of loans to village people who build successful businesses and contribute to local economies.[22] In all these experiments the emphasis is on small scale morphogenesis, which is coupled with an effort to maintain cash flows in the local region. The type of cash flows typical of these experiments are precisely those which are aligned with morphogenesis.

5. Protection Of Vanishing And Threatened Species of Animals, Plants, Birds, Fishes, and Insects.

The disappearance of species is largely a question of habitats disappearing, and the disruption of habitats. When we undertake planning and building through morphogenesis, one of the cardinal principles is that the latent structure that is in existence now, must be preserved, and improved, and extended – and when damaged, repaired. As a consequence of this principle, habitats of extant, weakened species must always, from the moment when the weakness first appears, be maintained and repaired and supplemented. An example of this kind of repair is that provided by the subsidies for rebuilding hedges in England, now made available by DEFRA (*Department for Environment, Food, and Rural Affairs*).

The repair of bird populations, butterflies and moths, under the impetus of this kind of program, is thus helped to take care of itself as part of an overall strategy, not only as part of a local ad-hoc action.

If all large scale planning were to be governed by morphogenesis, this would require that wholeness – defined, in part by the coherent wholes on the land, we supported, and strengthened. The two are, in this case, almost synonymous.

The creation of habitats, where they are inadequate or missing, would play a major role in almost all kinds of responsible morphogenesis, and would also arise, as a natural consequence of morphogenesis.

Thus, the program of planning itself, if done through morphogenetic processes, is likely to repair and rebuild species populations.[23]

6. Taking Steps To Protect Climate Stability

Possibly one of the most difficult tasks of all. Ozone, carbon dioxide, global temperature, cloud cover, ice age etc. In recent published discussion of this problem, the fundamental principle which has been enunciated is that the chaotic nature of the weather system, makes it amenable to control by very tiny regulations.[24] [25] It is significant that the NASA team studying this problem, have concluded that the approach is that of making very small changes which maintain the overall structure of

what is happening, while damping the damaging effects: an approach which is nearly synonymous with the morphogenetic approach, since the most fundamental concept is that of leaving the system alone as far as possible.[26]

7. Providing Housing With An Enabling Legislation, To Promote Self Housing In Neighborhoods And Cities.[27]

The growing move towards a

8. Changing The Local Use Of Cars Towards A More Pedestrian Emphasis

The growing move towards a more pedestrian emphasis, for reasons having to do with physical health, regeneration of community, and reduced reliance on external non-renewable energy resources, have all been coupled with an increase of morphogenetic process in the construction of the built environment. This occurs because the smaller scale and slower speed of pedestrian environments encourage differentiation and repair, while the more gross morphology of cars trucks and freeways, is less repairable, less well adapted, and less capable of sensitive adaptation to people, plants, animals and land.

9. Reducing Energy Use And Developing Renewable Energy Sources

This issue has been at the forefront of sustainable thinking, and is the topic which has been most frequently discussed.

10. Continuous Maintenance Of Every Part Of The Environment

This obvious and vital element of any living world, is surprisingly absent from most discussion of sustainable thinking. You cannot have an environment which works, unless it is truly, and literally, being sustained by improvement, repair, and continuous adaptation, continuously, and at constant intervals. Yet almost the only book on this subject is Stewart Brand's How Buildings Learn, which is rarely if at all, referred to in the sustainable literature.[28] How could something so centrally involved with the idea of what it means to have a self sustaining world, be ignored? One more bit of evidence of the invisible corporate background of present-day sustainable ideology.

Under conditions of morphogenesis, this idea of continuous repair and maintenance of the fabric of the whole, is natural, and inevitable. Adaptation of the system, is the central issue, and it must be dealt with daily vigilance. There is a continuous stream of

information about the things in the environment which are not working well, or not working as well as they should or could. To keep in touch with the process of ongoing adaptation, the environment must be made, and administered, in such a way that continuous repair of global; structure is natural, and inevitable. Thus conditions of morphogenesis require materials, and systems which are easy to fix, change, and reconfigure.[29] This does not point in the direction of the tinker-toy gimmicks of the 1970s. That kind of change has been proven ineffective, expensive, and unsatisfactory. Instead it points the way to a new generation of techniques, laws, and cash flow schemes.
See Dartington Estate, and its economy.

11. Ownership Of Habitat And Houses By Individuals, Even Under Conditions Of Poverty

The 20th century view of world housing was dominated by the notion that either governments or private commercial companies should be in the business of creating housing for the world's poor. Careful analysis of this idea has shown conclusively that it is only in the interest of the companies involved, and is not in the interest of the families and individuals who need shelter. It is not in their interest economically, nor is it in their interest as far as adaptation to their individual

family needs is concerned.[30] The ravage of land by developer's tracts is not helpful to the environment, nor to society.

12. Modifying the Development Process

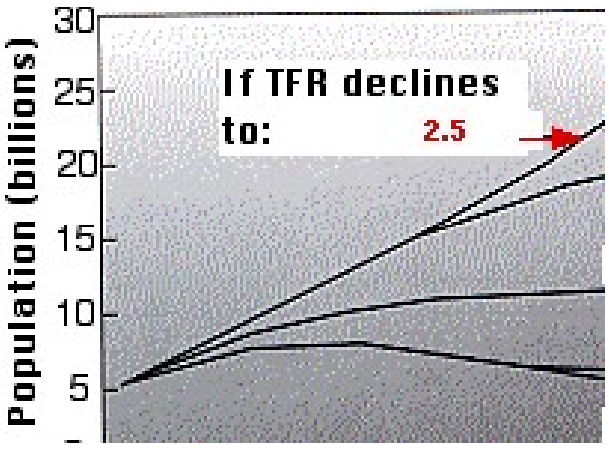
The largest single source of damage to the environment, world-wide, has come from the monolithic and centralized profit-driven corporations engaging in large scale construction of roads and houses and office buildings. For careful discussion of the more than twenty different ways this activity has severely corrupted the life-giving nature of construction process, see chapters 19 and 20 of Book 2 of *The Nature of Order*.[31] The essence of the problem, which reappears again and again in many different forms, is that local adaptation of land, buildings, interiors, spending of money, care of plant life, care of animal life, encouragement of local community, are all damaged by the careless and money-oriented work of a developer. You can only get the love and care required for true adaptation, from small scale effort, by thousands of people, protecting and caring for what matters to them on their own land. This is profound connected to the idea of communal morphogenesis, and stems from it, since it is only this kind of thoroughly decentralized human effort which can make sure that each local act is

both adaptive, and also oriented towards the growth and emergence of organic, not top-down, not imposed, global structure.

13. Stabilizing World Population

From the point of view of sustainability, it is the world population which dominates the problem and the difficulties. Issues of food, agriculture, climate, effluents from production, all become more and more acute as the population increases. In the year 9000 BC, the world population was about 5 million. In the year 1 AD it was about 200 million. In 1600 AD it was about 500 million. In 1900 it was about 1.5 billion . Today it is 6 billion rapidly approaching 7 billion.[32]

The pressure on resources, the negative consequence of too-great a population density (not only for human welfare, but also for animals and plants) is enormous. The aim of a sustainable world cannot be reached unless the total fertility rate, worldwide, reaches levels in the neighborhood of 2.0. It is now about 2.8. Kimball summarizes the situation this: The graph below (based on data from the UN Long-Range World Population Projections, 1991) gives 5 estimates of the growth of the world population from now until 2150, assuming that TFRs decline from the 1991 value of 3.4 to the values shown. [33]



- A value of 2.17 (only 5% above 2), would by 2150 produce a population of over 20 billion and still rising.
- A value of 2.06 will produce a stable population of about 11.5 billion.
- A value of 1.96 (5% below 2.06) will cause the population to drop back to close to its present value (6.1 billion) while
- A value of 1.7 by 2150 would allow the population to drop back to about 4 billion.

Now, how is all this linked to morphogenesis? And is there a way in which morphogenesis of the physical environment plays a necessary role in the effort to stabilize the human population?

I believe it could be feasible to imagine a system effect through which large scale planning and construction through morphogenesis, would have a subtle system effect on slowing down the population growth itself. The way this might work is through a global mechanism not unlike Lovelock's daisy world.[34] The practice of widespread morphogenesis can encourage, and ultimately require, participation by all individuals in the complex adaptive process which generates our world environment. This requires care, affection, and time, so that people can decide slowly, what is important to them, and then build it, or guide its construction, gradually in their own surroundings. All this is at odds with the non-sustainable corporate model of population growth, and huge capital investment to create apartments and condominiums and slums for people to inhabit. Thus the process of morphogenesis, by stimulating and encouraging care and slow development of every family environment, could discourage population growth, and encourage, rather, careful adaptation and the creation of beauty, thus helping to reduce the world population as part of its overall system effect.

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I hope you can now see how the vital technical issues inherent in the construction of a sustainable world, must be conceived and implemented within the framework of an overall piecemeal, morphogenesis, all over the communities and buildings of the world.

It is this approach, and I believe, only this approach, which can make genuinely wholesome buildings and neighborhoods, in keeping with the philosophical aspirations of the ecology movement.

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- The movement of every system, and every part of every system, is always a movement of the whole, though it goes forward incrementally in small steps.
- The incremental change and adaptation is going on all the time.
- What moves forward, is always “the whole.” In morphogenesis, each movement forward addresses the entire system, with special reference to its configurational wholeness, and preserves and extends that wholeness through the small incremental acts.

- Minute adaptation and repair are going on at every level, continuously.
- The wholes which emerge, and continue to emerge, derive from the wholes that were there just before, thus creating historical continuity, cultural continuity, and morphological continuity with the form and essence of the land. This is the essential principle of wholeness-preserving transformations, mentioned repeatedly in the text above.[35]
- The minute and careful adaptation of land, requires (and cannot do without) intense participation by people who live in a place. They need to have caring and emotional ownership of the places where they work and live. This participation cannot be passive (a bureaucratic arrangement where people are led and fed to stand behind things). It must be an active process that allows people do what they really and truly want to do, while yet taking care of the neighbors' fences and trees, and the larger configurations required by the local community.

XVI The Eishin Campus

In the next forty pages, you will see pictures of the Eishin campus, a place which has an unusual sense of life. I am showing this, because it is time to show you that morphogenesis, when properly carried out in a large community or building project, can create a genuinely living community, where people, water, plants are healthy, at ease and self-sustaining. I hope you will notice that the life visible in this place is not only an ecological life, but is a life that is visible in people faces, in their activities, and in their attitude towards each other, in their attitude of spirit. In short there is a spirit in the place.

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During the 1980s, my colleagues and I from the Center for Environmental Structure, built a large project outside Tokyo. It is a campus for a combination high school and college, and stands on what used to be tea bush land, and it's about 300 meters by 300 meters, some nine city blocks. A reasonably big place. The work was done in conjunction with about a hundred staff and students of this place, while the school was

still functioning in its temporary home in Musashino-shi, a suburb of Tokyo.[1]

We began by working with the students, staff, and teachers of the school to construct a pattern language which would capture as much as possible of their aspirations, their feelings, their needs, their mental and spiritual comfort.

You may say, if you like, that we were probing the reality of life, as they experienced it. This work took several months.

The project began with the construction of the pattern language. We spent the first few months constructing a new pattern language just for the new Eishin school. The very first thing I did, in order to get the pattern language, was to spend two weeks just talking to different teachers and students, to get a feeling for their dreams. The kind of talk, was as deep as I could make it. I asked people about their longings, their hopes. I asked people to close their eyes, and imagine themselves walking about in the most wonderful place they could imagine.

It was very hard to do. I tried, at one point, to ask some of my assistants who could speak Japanese, to do the same. But they were sometimes too polite, and

[1] This work of writing and constructing the pattern language for the Eishin project was done with Hajo Neis, Ingrid King, Hiro Nakano, and other members of the Center for Environmental Structure, always working, daily, with the people in the school.

tended to ask questions which were too commonplace, and not inspiring. My effort, in these conversations, was to try and reach the deepest place in people's hearts, and to force people to bring the material from this deepest place, out into the open.

For example, if you ask a person what is wrong with his classroom, or what kind of classroom he would like, he will probably give you an answer which is very similar to what he has already, or to what he is used to, because he thinks, that there is no way of escaping from this, and is trying to be helpful by accommodating to the framework of system A, as far as he understands it. Thus he is already making assumptions that system A is inevitable, and that he must stay inside system A in order to be helpful.

But if you ask him, instead, to close his eyes, and imagine that he is in some kind of heaven, and that he is teaching for the first time in his life in a place of perfect harmony -- then this question invites him to escape from system A. Even so, in real cases, he may often refuse this kind of question -- by saying things like "I don't know, I don't really have any idea..." I am not quite sure what kind of thing you mean...<170>, and so on.

But you must then insist, give him encouragement, take away his fear of leaving system A. If you are persistent enough, sooner or later he will start really telling you his dreams. He will relax, and enter into another world, where his own feelings are the

main thing, and where his love of human reality and human feeling is the governing force.
At this point his work, his answers become profoundly useful.

But the main trouble with my less experienced assistants, was that they could not probe with this kind of insistence, because they either didn't have the confidence, or more likely, because they were themselves so deeply trapped in system A, that they were quite incapable of helping someone else top leave it. Even someone like Hiro Nakano, though aware for years of the troubles and difficulties of system A, was not deeply enough anchored in real experience of system B to be able to help people tell their dreams in an effective way.

Also, the patterns had to fulfill a *generative* role. Each pattern, when read, had to evoke a physical, morphological, and visceral feeling in the reader, both generative specific visualizable form, and also creating a visceral feeling of well-being in the reader, one which contributed to one's well being.

Once the pattern language had been approved by the entire body of the school, trustees, teachers, staff, and students, we then entered the next phase during which we applied the pattern language to the land, to get, what would typically be called 'the plan.'

During this time we assessed the potential of the tea-bush and agricultural land, the structure of the place, marking all the centers which were visible there, as the land existed at that time.

Members of the community looking out carefully at the land, together, to find out what to do next

The pattern language (containing about 200 patterns) was organized in an overall sequence. Roughly, the largest patterns – those which had a physically large scale, or those which had the most decisive impact on the campus overall layout – came

first, and the smallest patterns, dealing with morphologically small effects came last.

Some of these morphological steps were arduous. By that, I mean that it was hard to achieve them, and make the steps coherent.

For example, the very earliest step, concerned the location of the entrances to the campus; another early step decided on the relative location of the college and the high school. Another made the lake for the college, coincide in position and extent, with a swamp where vegetables had been grown in the past. Yet another decided on the southern ridge as a beautiful and important part of the land, which had to coincide with some very important part of the campus complex.

These steps were worked out, first on a large scale model, and then on the ground itself, among the tea bushes. We began placing flags out on the land, trying to make the patterns come to life in the actually place where the buildings were going to be.

Hosoi and I arguing, having a discussion, and thinking together, about where a certain flag should be, while placing the flags

The next picture shows you just a glimpse of what it was like out in the tea bushes, laying out the buildings which were to be. It was like a film of Kurosawa.

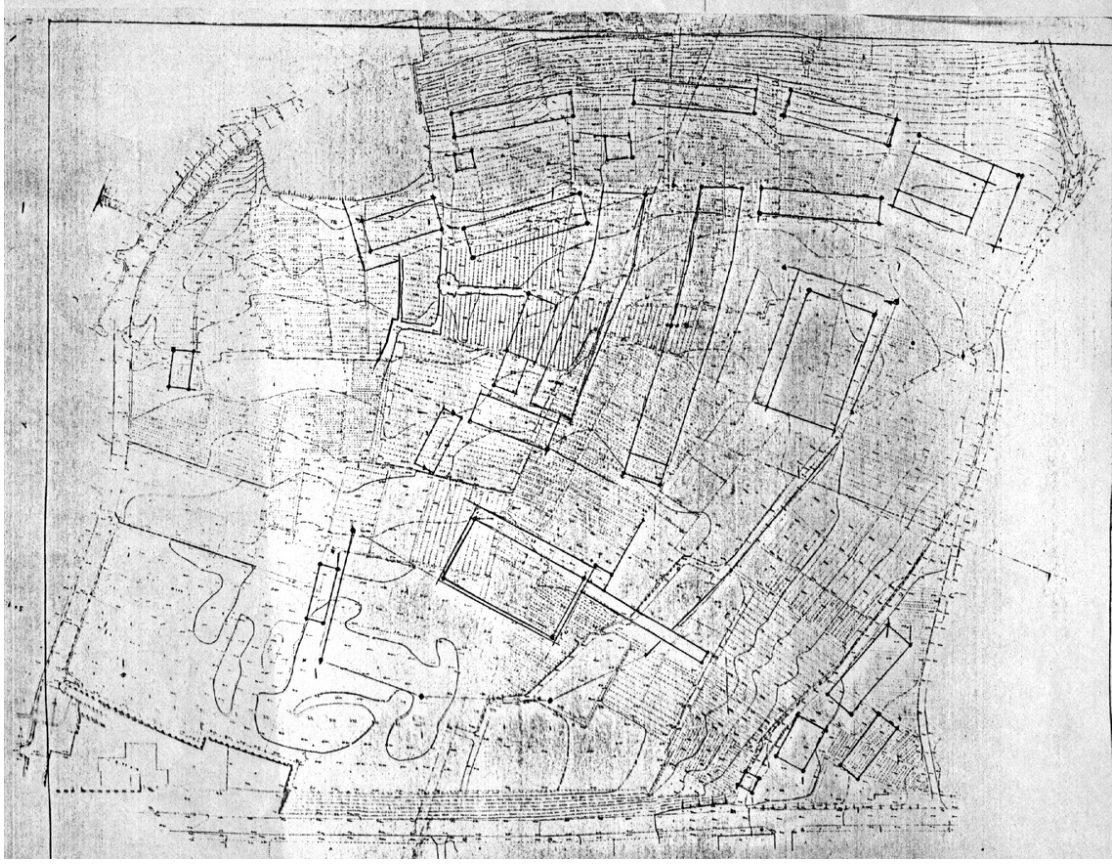
The flags we used to lay the campus out

It took many days of course, and we did it gradually. Then, after we had all had a look, and moved flags, and moved them again, and moved them again adjusting subtleties, … then finally, we measured the position of the flags very carefully. The result of that work was captured in a measured drawing (shown on page 208).

The situation shown in the photo on page 206 was well into the process. We didn't just walk in and start laying things out. There had been about six month's work on the Pattern Language, with the community of the staff and students. And that pattern

language was then implanted into the land, and these flags were used by us to establish how buildings should be there.

This was a most unusual process. Normally, in conventional 20th-century planning, the architect made a drawing, on paper, in his office. And the marks he made on the paper, were then transferred to the land, and the result of that process was then built. But of course this process was not capable of making places which truly arose from the land, or which were deeply rooted in the feeling of the land.



The drawing we made by transcribing the positions of the flags to a topographical plan. This became the final plan of the campus

Instead, we followed this new process, which naturally allowed the marks of the design and plan, to arise from inspection of the bushes, and slopes, and landmarks, and occasional swathes, and views, and steps, and watercourses. It allowed us to see what had to be done, with our own intuitive feeling for the land and its wholeness.

The measured drawing was a drawn after we had been out there, and it gave us the positions of the outer space and buildings.

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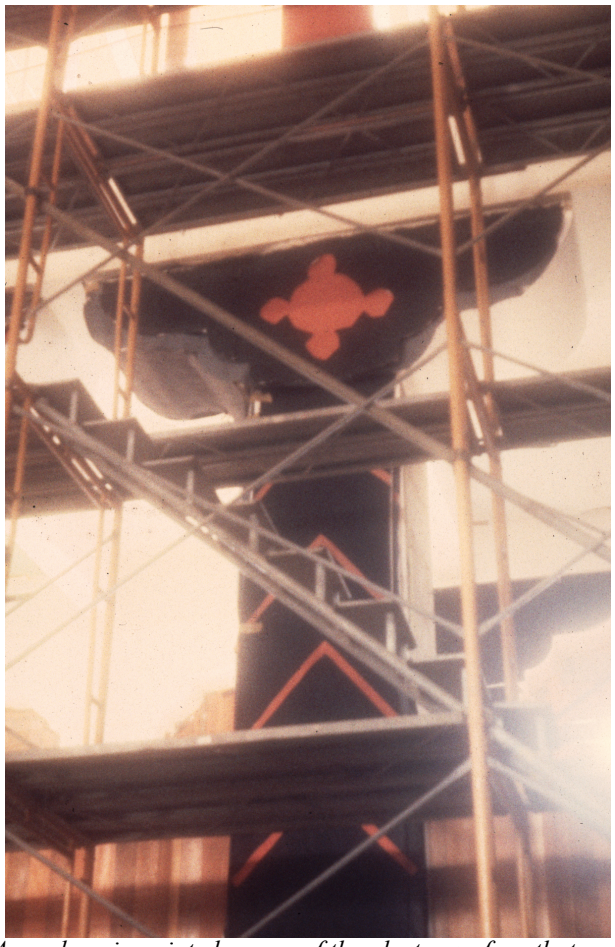
And then, with that fixed, we used similar morphogenetic techniques when the buildings themselves were being thought out and built.

So we were constantly doing what morphogenesis told us to do. In the case shown on page 211, we were laying out the width, exact shape, and position of the main entrance street of the campus. We were able to place it accurately, because the steel structure of the Great Hall was in position, we could

Modifying stakes to mark the entrance street, once the volume of the great hall was in place, and allowed us to make more accurate judgments about the angles and positions of the street and its edges.

visualize the Great Hall standing there, and could therefore make exact measurements of the desirable positions for the entrance gate, the walls enclosing the entrance path, and so on.

While individual buildings were being built, once again we made mock-ups of most of the buildings, and their interiors (here is an example of a mockup for color in the great hall, page 212). For every building, we made mock-ups of how the building went. And until we got what we felt was the best that we could get it to, we didn't stop. It was a slow, empirical process.



A mockup, in painted paper, of the plaster surface that was to be put on the great hall columns

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HERE, NOW, IS THE CAMPUS WE BUILT, USING MORPHOGENESIS, THROUGHOUT

The Eishin Campus from a distance, in the snow

A part of the campus where we preserved tea bushes, and built up the banks of grass, in the place where students came to have their lunch

Rain and students coming to the campus

Water's edge: the classroom buildings along the lake we built

The Central Building, a multipurpose hall for students

All of what I'm showing you here are things that we built. Again, I want to emphasize that in every single case, morphogenetic methods were used to get the results that you see here. And this gives you some feeling for how people are in that place, and how much they feel at home!

Break dancing in the Central building

The students' boat at festival time

In time of snow: one of the classrooms and its garden

The Cafeteria

A favorite spot: Students on the roof outside their classroom, overlooking the main street

Hisae Hosoi, the chief administrator of the school

One of the arcades of the college buildings

Students congregating in the main street of the high school

To the right, the great hall, already in use, even while it was still under construction

Volleyball courts on the campus

The gymnasium: the largest all wooden built in Japan in modern times

Great hall stage, during a major concert

Classroom, attention, soft light

Part of the Great Hall in an earlier state, with all white plaster

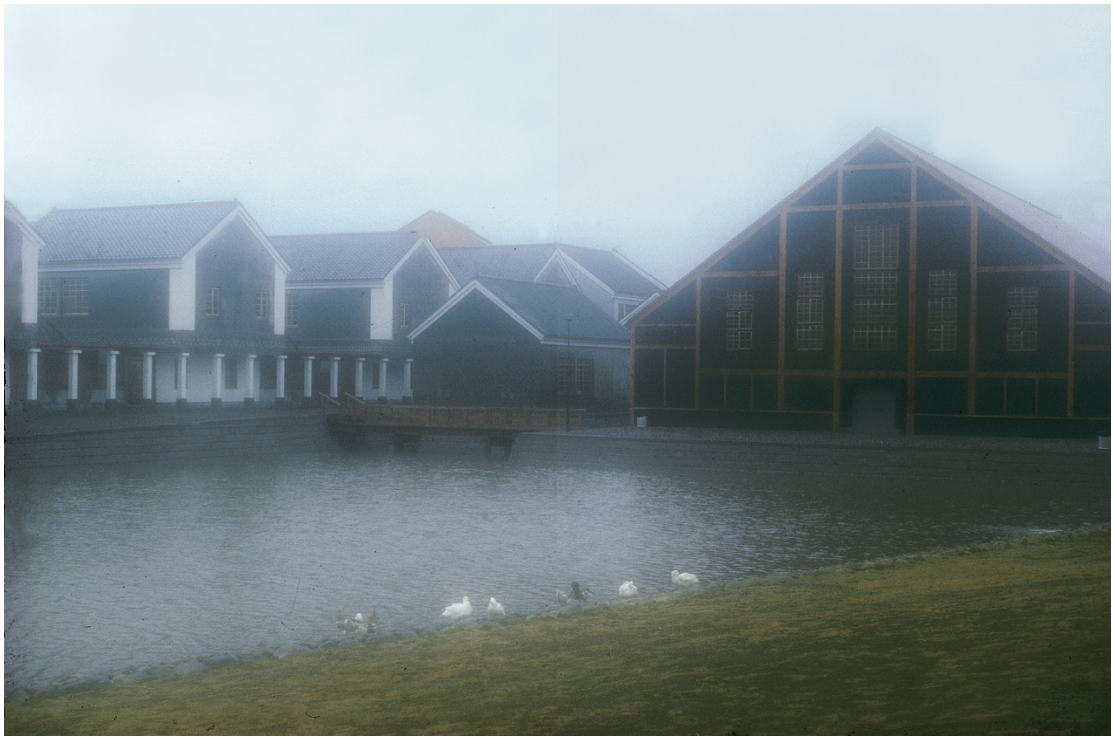
Garden of the Faculty building, seedlings, tea bushes

Inside the music school

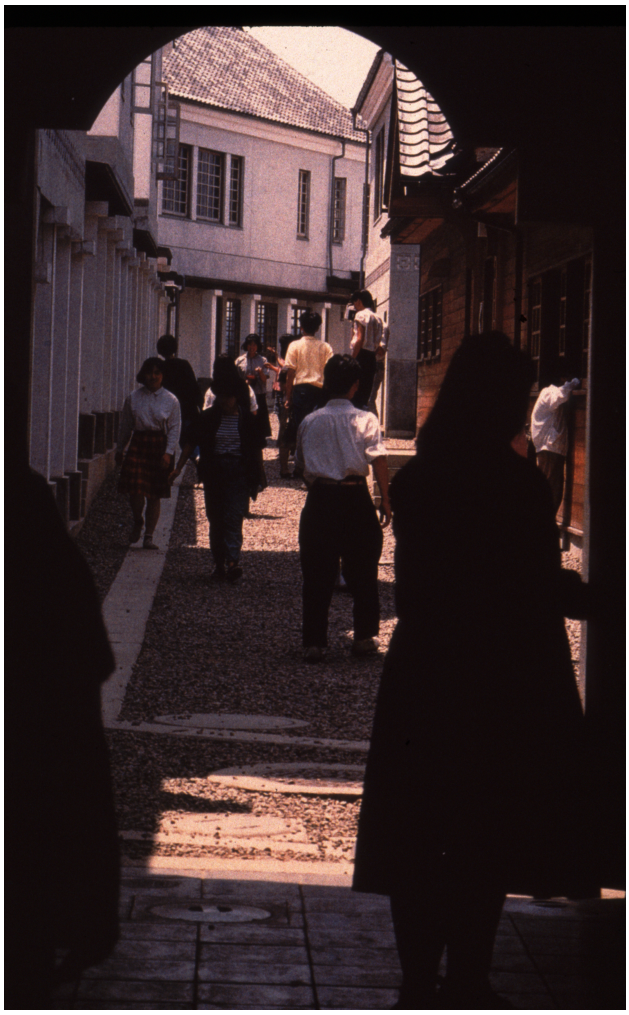
The loose and beautiful atmosphere of students in the space outside the Great Hall

The clubhouse – a building donated by families of graduated students, not in gratitude, but so that they, too, graduates and their families, could legitimately come to the campus and be there, years after graduation, and maintain a presence and a foothold there, because they loved it and wanted to keep their memories alive

In time of rain, the main street of the Campus



The lake we built, the arcades and classrooms around the lake, and the gymnasium



One of the internal pedestrian streets of the campus

Another of the internal pedestrian streets of the campus

Evening light on the whole campus

I vividly remember once, an incident on campus. A Japanese director, Mr. Kawazoe, was making a movie about my community work, and part of his film was about this place. An some point in the filming of the movie, he got hold of an art student, pulled him aside, and asked if he were willing to talk on-camera with him, the director. " . . . Just talk to the camera while I'm filming the camera, make a few comments about this place, tell me about your life here . . ." The student was wearing a black turtle-neck sweater, was very austerely dressed. And he said, "Yes I grew up in Tokyo. My life in the streets of Tokyo was like a dog. I was always parched emotionally and physically, and

ran hectically about the city streets as if with my tongue hanging out. And when I came to this place, Higashino, and passed through this gate, . . . " He paused and stared into the camera for a few seconds, in silence. Then he said " . . . for the first time in my life, I felt that I was free . . ."

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So in conclusion, I suppose it is fair to say a few words, in general, about the process we followed, and its results. All this stuff about morphogenesis I have been describing, may perhaps sound elaborate, even rather theoretical. But you can see from these pictures that the impact of this new view of architectural and ecological process is not theoretical at all. It has *dramatically* different effects on the environment that is created, and consequently also has dramatic effects on the well-being and communal feeling of the people who live and work here.

In my eyes, this gives us an entirely new view of what is sustainable: *What is sustainable, is what supports the earth morphologically*. And what supports the earth morphologically, is what unfolds according to the wholeness-preserving nature of morphogenesis.

This view of sustainability is not a technocratic, money-inspired, soulless, use of gadgets and their

production, but is rather a truly visionary, and scientifically sensible view of how nature unfolds, and how our settlements must unfold, in the same way that nature does. But since it is architecture with nature, not only nature alone, that unfolds, it produces types of geometric structures that are unique to buildings and human beings, still "natural," still profoundly helpful to the beauty of the earth, and still always preserving the deep structure of the earth.

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XVII Schumacher College Extension

Many of you may know Schumacher College on the Dartington Estate in Devon. In 2004, I had the opportunity to demonstrate the difference between a morphogenetic approach, and the present-day technical approach to sustainable architecture. Schumacher College had been considering a design for an extension. It was designed by Tim Ronalds, an architect well-known especially for his skill in dealing with topics of sustainable design. Professor Brian Goodwin, head of the Masters' program at Schumacher College, was unsure about the validity of Ronald's proposed design, and asked me to demonstrate what kind of project was likely to emerge if a morphogenetic approach were used instead. I agreed, and he then commissioned my firm,

Schumacher College as it now exists: The front of the building known as the Old Postern

the Center for Environmental Structure, to make a rapid assessment of the likely results from a morphogenetic process. first phase design for the extension.

The process we followed was extremely rapid, in considerable part because the College did not have the money to do more, and time was also running out at the end of the academic year. We did not, therefore, even attempt to construct a pattern language for the project, and also had to make do with a dramatically curtailed version of the involvement of users – i.e. staff and students: once again, we just did not have time.

Instead, we focused primarily on the unfolding of the geometry, as it was likely to come out, and to show (as seen in the pages below) the startling differences in morphology which did in fact occur, in comparison with the conventional design process that had been followed by Tim Ronalds.

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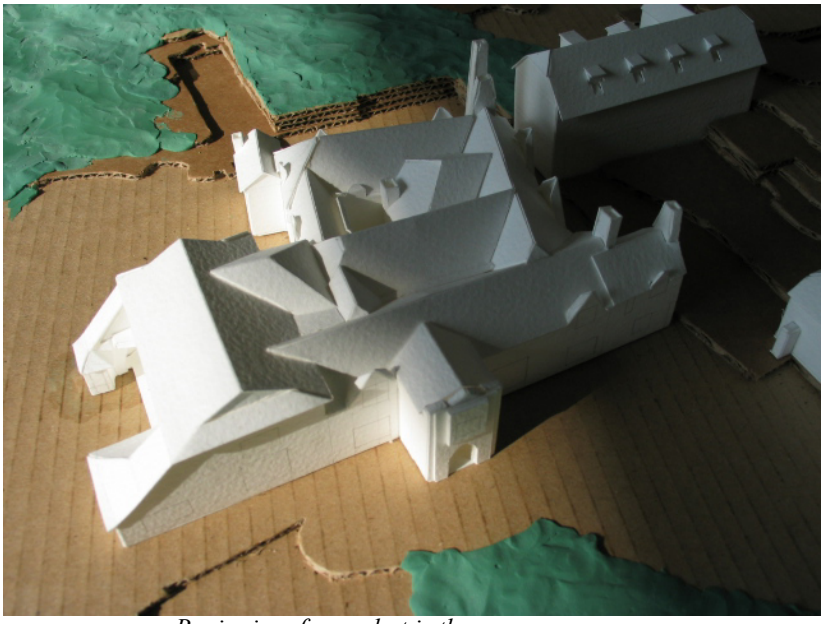
We started by making an assessment of the situation as it was, and to do this we began by building a site model, with detailed contours, showing the terrain in its three-dimensional form. And once this site model had been built, we built a a cardboard model of the Old Postern Buildings, showing all its ins and outs, its lovely roofs, and the particularity of the places and volumes which existed.

Up the front path

Roofs from the back



Beginning from what is there now.
We built this small model of the present Schumacher College and surroundings and topography, so that we could use it as a laboratory to investigate the impact of structure- preserving transformations.

Representation of the circle that one can feel in the land and the front of a possible terrace.

Beginning of the morphogenetic process. We could see and feel a circle in the land, and knew it would be important in guiding the development. And, even in this earliest move, we suggested a curved terrace in front of the building, reflecting the circle, and making a place of repose.

The new courtyard and the circle in the land are integrated. The curve of the new courtyard replaces one edge of the circle. In addition, the buildings in the lower part of the picture are retained with their physical fabric only slightly modified, thus maintaining continuity with the character and structure which exists.

Looking up the front path of the real place. Then imagining how this view might be transformed to include a configuration in harmony with the wholeness that is there now.

Looking up the front path, making the main dome golden, seeing a forest cathedral made from the tall trees at the back of the old Postern

A connective path to the forest garden behind the college

A path is made to the beautiful biological experiment known as the forest garden, thus creating a usable connection to the land lying north. The gate to this path passes under the golden dome.

Trying domes: Bankoku Sasagawa, one of the CES staff, working on the model

Trying different dome shapes and sizes, to find the best fit to the land and to the existing buildings. Even the small extensions visible in the upper buildings have common lounge areas approachable from the outside, and are also marked by small half-domes.

In the trees. Here we see the result of a policy of subtle adjustments, reaching out into the land in all directions, and maintaining connection with the trees and forest cover on surrounding land, so that it all becomes connected, and maintains its wholeness.

In this state of the model (previous page) you also see how the circle in the land has been memorialized in small megaliths, standing about 30 feet apart, and standing upright in the grass, to mark the original circle that was observed.

Now we had to find out how big these stones should be!

Testing a mock-stone in place for one of the circle stones

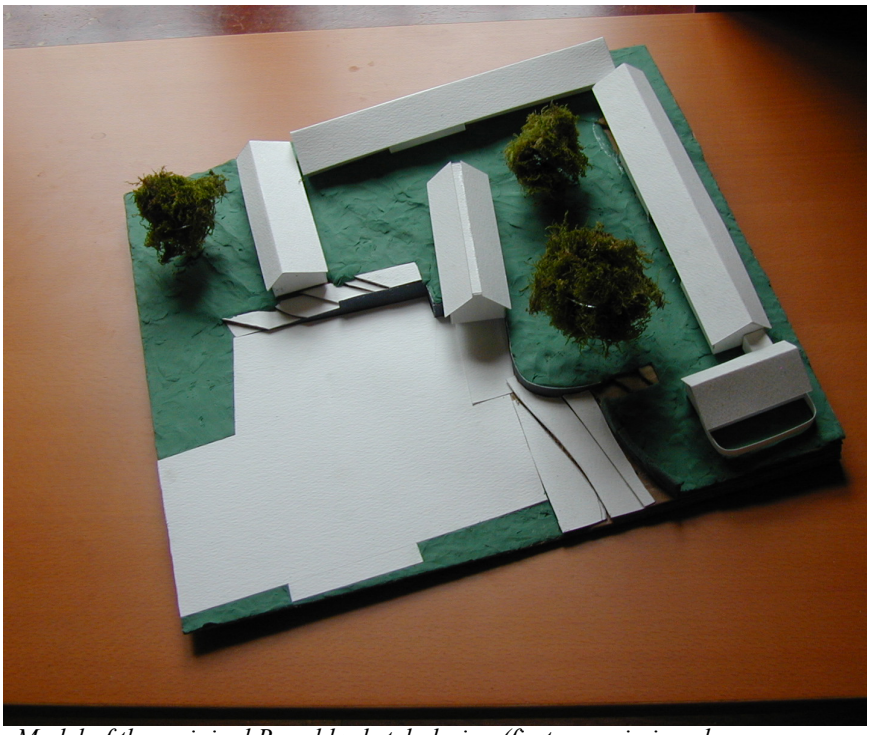
Testing a smaller stone (visible behind the twigs) which fits better and is less aggressive

A sketch of a new library re-using an existing building, but modifying it to honor the land, and made in a way that has some spirit -- with green glass and plant-like tracery to form windows of a special character reflecting the values and philosophy of the College.

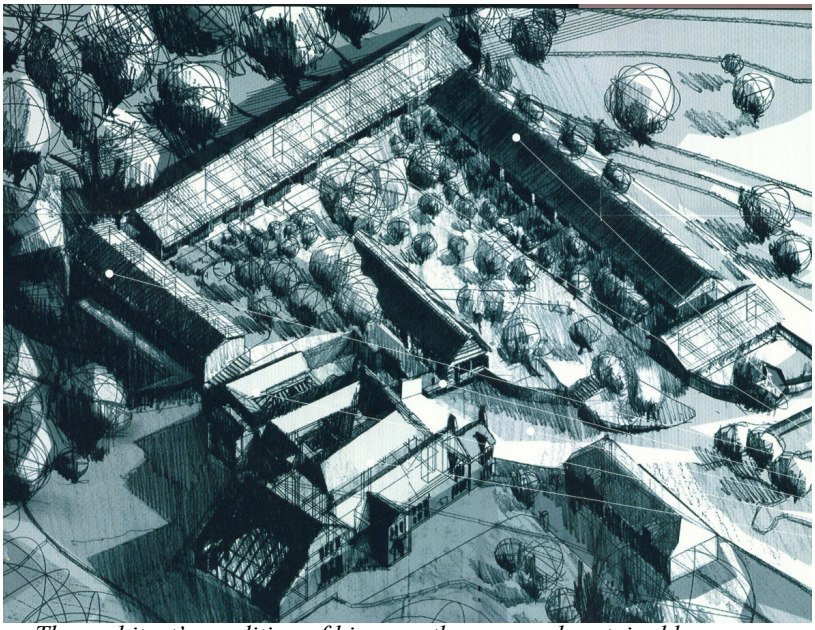
Testing the appearance of the new Library windows on the model

Director of Schumacher College, Anne Phillips and Chris studying the model together

A More Technical, And More Conventional, "Sustainable" Approach



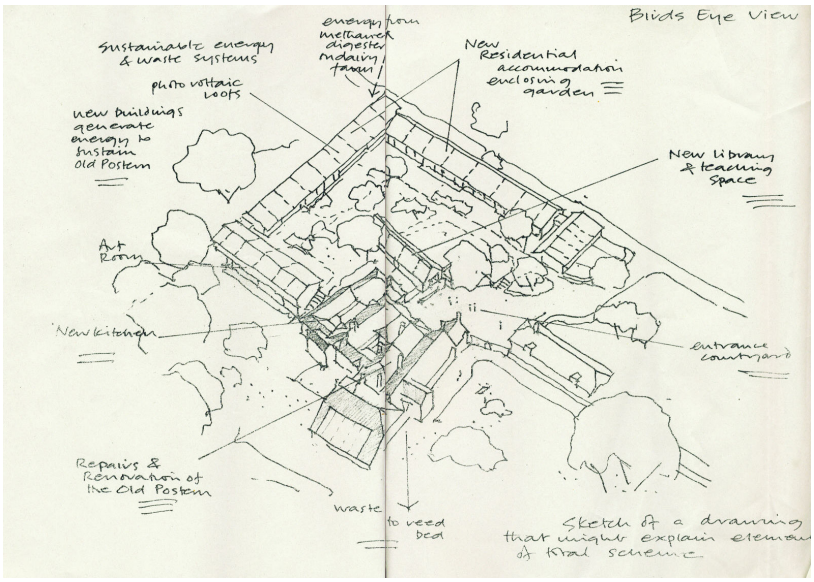
Model of the original Ronalds sketch design (first commissioned by Schumacher college). We made this model, in three dimensions, and at the same scale as our model, so that the two could be compared. The white area bottom left of the photograph, represents the footprint of the existing Old Postern building. We did not have the resources to duplicate a second Postern mode for this design, and it was impossible to remove it from the other.



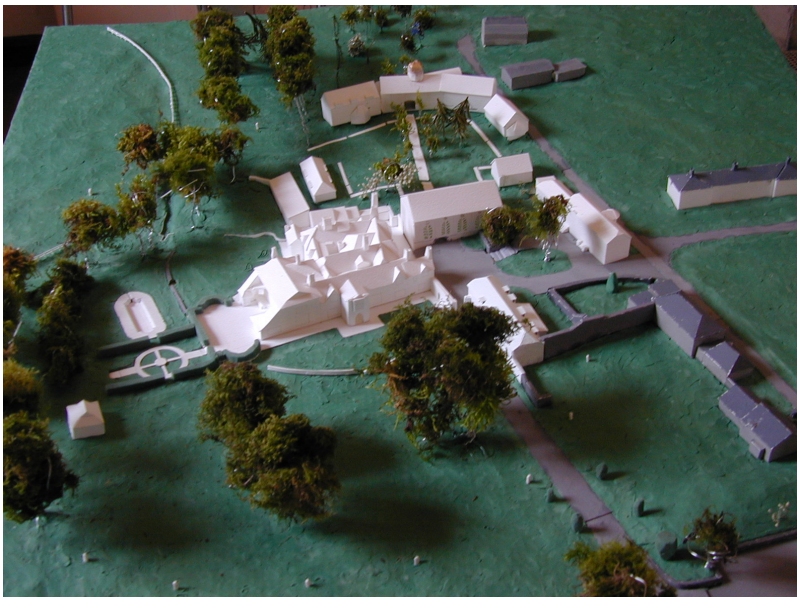
The architect's rendition of his recently proposed sustainable design with re-use of rainwater, thermal walls, possible solar panels, roofs oriented to sun.

This design is more technical in orientation, but done with less concern for the wholeness of the land, and less awareness of the wholeness that is present in Schumacher College as it exists today. It pays less attention to the configuration that has grown over time, and for the subtle harmony to be achieved by building on what is there already. I believe it is also less sustainable in real terms and in terms of sustaining

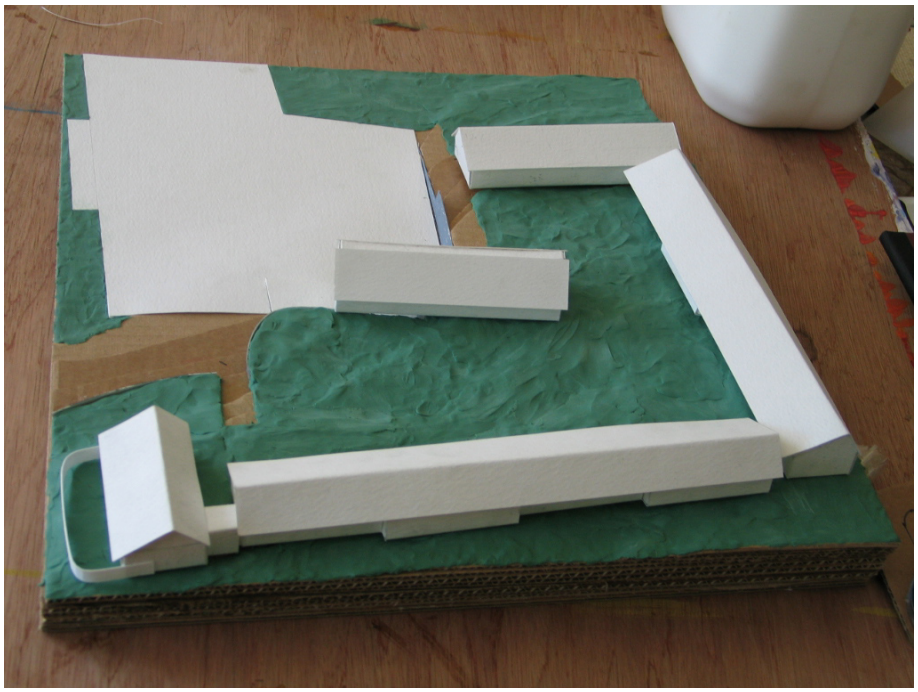
human life and plant life and money. It also involves needless destruction of existing buildings.



Architect's own sketch of techno-scheme. It includes photovoltaic panels, reed-bed sewage treatment, sustainable energy and waste system . In theory it is sustainable. Indeed, it is plain that the architect made a very sincere effort to incorporate all available technical-sustainable thinking.



CES design overview, seen from the east



The Ronalds design, also seen from the east.
A sustainable design, when it is made according to technological views of what is sustainable

Clearly the technical solution is intended to be sustainable in all sense of the word. What is remarkable is that, in comparison, this project appears gross and without levels of scale. That is, I believe, a direct result of the approach used to produce the design. The technical approach focuses on a narrow range of issues and emphasizes them, above all others. The whole point

of the morphogenetic approach is that it produces finely detailed structure, at a variety of scales, and produces sustainable and coherent wholes, at all the intermediate levels of scale, that are appropriate for human life, social life, biological life and ecological life.

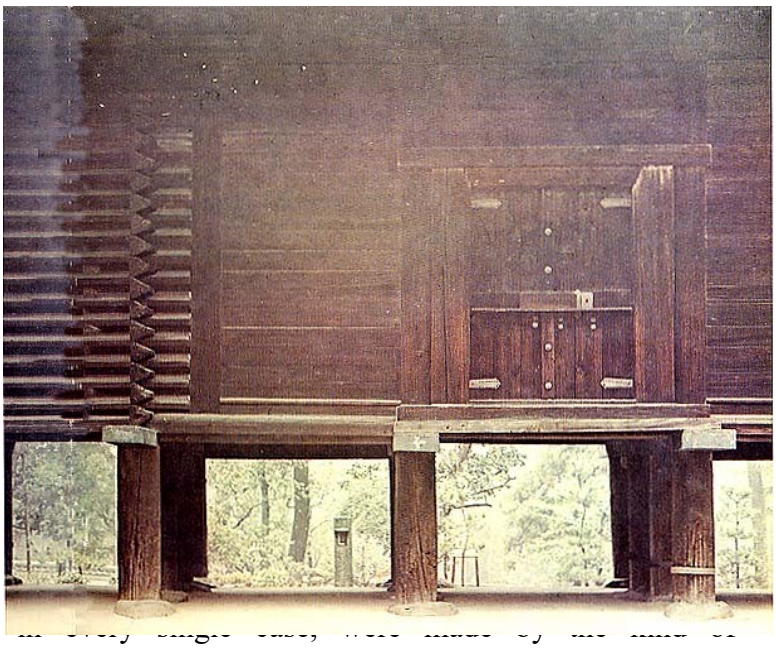
What the morphogenetic approach generates – if it is done correctly – will always be something like this:

A living result of morphogenesis

A design made through a process which allows each step, slowly, slowly, to preserve the existing whole, and create something that fits into, and enhances, and makes precious, the existing land

XVIII Approaching the Human Soul

In conclusion, I think it would be helpful to show you, now, a few pictures of some great places of the spirit, that have been made by human beings.



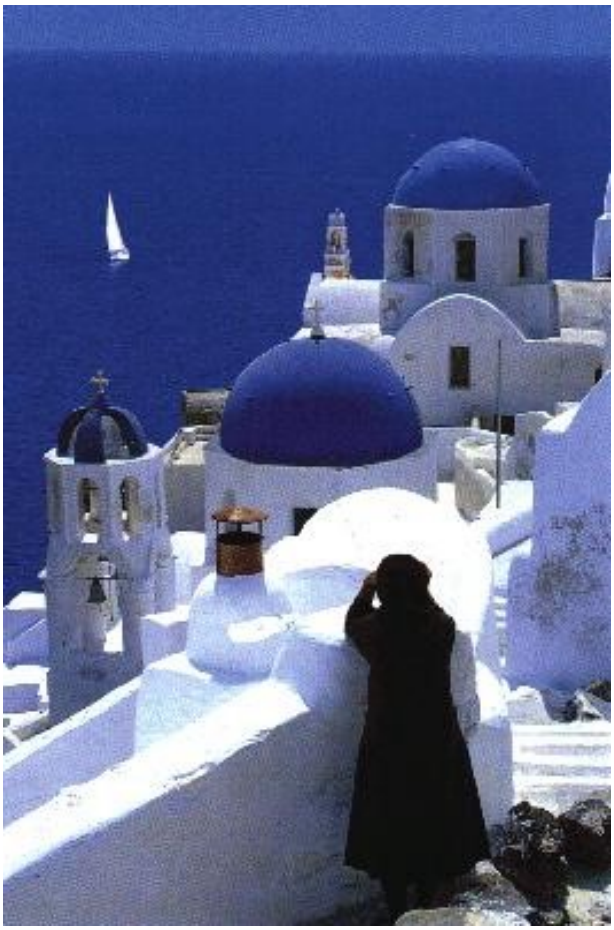
morphogenetic process I have been talking to you about.

Church in the Aegean sea

This church, for example, was made, undoubtedly, by builders and priests who decided every detail just as it came up, and made the decisions, one by one, in relation to the land and rock and sea.

Mikonos

These things represent true sustainability, they sustain the heart, and sustain the soul. They sustain the humanness of the person. And they sustain the Earth.



Another church

Another part of the Aegean

Sand Garden of Tofukuji

To-fuku-ji. One of my favorite temples in Japan. It was shown to me (in 1967), by two elderly Zen masters, who told me it was perhaps the last place where the true spirit of Zen was still alive.

The bridge at Tofukuji

The Moss garden at Tofuku-ji

The very last picture, on page 272, shows a temple called Myo-Honji in Kamakura. In Japanese, the phrase “myo-honji” means “subtle reality temple.”

San ju san Gen do – the thirty three bay temple in Kyoto
with a thousand golden buddhas

Myo-Honji, Kamakura.
In Japanese "myo-honji" means "subtle reality temple"

I was going to show you other things, but I think it's probably in everybody's interest that I don't. So I will stop now….So thank you very, very much. Very lovely, lovely, thank you so much.

Thank you very, very much, for listening to me.

Appendix
An Economic Model for Continuous, Ubiquitous Repair.

NOTES

[1] Christopher Alexander, *The Nature of Order*, Four volumes, Center for Environmental Structure Publishing, Berkeley, California, 2002-2005.

[2] John Steinbeck, *The Grapes of Wrath*, Penguin classics paperback edition, 2000, page 85.

[3] A notable exception is the paper "Using mechanics to map genotype to phenotype," Mark Miodownik, in Kumar and Bentley, *On Growth, Form and Computers*, Elsevier 2003, 203-219.

[4]

[5] Text on structure preserving.

[6] A full discussion of this type of process is given in The Process of Creating Life, Book 2 of The Nature of Order, Berkeley 2003.

[7] Will be available on the CD of wholeness enhancing processes.

[8] See discussion in *The Nature of Order*, Book 1, chapter 5, pp.xx-xx.

[9] These fifteen operators are described at length in in *The Nature of Order*, Book 1, chapters 5 and 6; and again, in their dynamic aspect they are described in Book 2, chapter 2.

[10] Reference NofO.

[11] The following discussion is a drastically reduced summary of the empirical findings reported in Book 1 of *The Nature of Order*, *The Phenomenon of Life*, CES Publishing, Berkeley, 2002, see especially chapters 8 and 9, pages 313-70.

[12] This question, and the many ways of asking it, are discussed at length in chapter 9 of Book 1 of *The Nature of Order*. The chapter is called *"Beyond Descartes: A New Form Of Scientific Observation",* and indeed the whole chapter is devoted to this question.

[13] See chapters 1-17 (pages 15-494) of *The Nature of Order*, Book 2, *The Process of Creating Life*, CES Publishing, Berkeley, 2002

[14] *The Nature of Order*, Book 1, *The Phenomenon of Life*, pages 143-296.

[15] This idea first brought up in *A Pattern Language*, Site repair, and in *The Oregon Experiment*.

[16] See pages 518-19 and following pages of *The Nature of Order*, Book 3, *A Vision of a Living World*, CES Publishing, Berkeley, 2005.

[17] Ibid, pages xxx-xx.

[18] See discussion of the Austrian community of Gruessing, more than 90% self sufficient in energy.

[19] Stuart Cowan, Conservation Economy, with Ecotrust, http://www.conservationeconomy.net

[20] Myanmar at a Glance, World Bank, website http://www.worldbank.org/data/countrydata/aag/mmr_aag.pdf.

[21] See Alan Weisman ***Gaviotas****: A Village to Reinvent the World*, Green Books, 1998.

[22] Grameen bank reference.

[23] DEFRA subsidy program

[24] **"Macro-engineering options for climate change management and mitigation" , Isaac Newton Institute in Cambridge from 7-9 January, 2004. Cambridge UK Conference Look Into Climate Engineering, January 26, 2004**

[25] **Toni Thayer, Global Weather Control System: Flurry Of News Stories Just Released**

Hoffman, R. N., 2002: Controlling the global weather. *Bull. Am. Meteorol. Soc.*, **83**, 241–248. also

Ross N. Hoffman, Controlling Hurricanes: Can hurricanes and other severe tropical storms be moderated or deflected? Scientific American, October 2004.

Ross N Hoffman, *Controlling the Global Weather*, Atmospheric and Environmental Research, Inc. PDF **...**
http://www.niac.usra.edu/studies/study.jsp?id=715&cpnum=01-01&phase=II&last=Hoffman&first=Ross&middle=N&title=ControllingtheGlobalWeather&organization=AtmosphericandEnvironmentalResearch,Inc.&begin_date=2002-03-0100:00:00.0&end_date=2003-01-3100:00:00.0 02/18/05, 5399 bytes

[26] Ross N. Hoffman, Christopher Grassotti, John M. Henderson, S. Mark Leidner, George Modica, and Thomas Nehrkorn *Controlling the Global Weather*. Atmospheric and Environmental Research, Inc.
131 Hartwell Avenue, Lexington, MA 02421-3126 Telephone: 781.761.2288 15 July 2004 **Universities Space Research Association (USRA), NASA Institute for Advanced Concepts (NIAC)**

[27] Shlomo Angel, Housing Policy Matters, Oxford University Press, New York,

[28] Stewart Brand, How Buildings Learn, …

[29] John Holland, Complex Adaptive Systems, …

[30] Shlomo Angel, *Housing Matters*, Oxford University Press, 2001.

[31] See *The Nature of Order*, Book 2, *The Process of Creating Life,* CES Publishing, Berkeley, 2003, pages 511-50.

[32] *Historical Estimates of World Population.* Source: U.S. Census Bureau, Population Division, International Programs Center. Last Revised: 26 Apr 2005

[33] J. Kimball, Human Population Growth, *Kimball's Biology Pages*,
http://users.rcn.com/jkimball.ma.ultranet/BiologyPages.html
September 2004. Diagram courtesy of John Kimball.

[34] Lovelock, The Gaia Hypothesis, ..

[35] Pages 2-3.