try as before, but less of it; and the irregularity lies between the drops. Again, the system wants to preserve as much symmetry as possible: when the perfect symmetry of the endless thread is broken, we get the slightly less perfect symmetry, but symmetry nonetheless, of the regularly spaced line of droplets.[5]

These are examples of explicitly structure-preserving transformations from the literature of physics. In each case, the wholeness is a system of symmetries and centers. When something is done to the wholeness, or some effect is introduced, differentiation is created. The particular differentiation which occurs is that one which is most fully structure-preserving. This means that a step forward is taken which leaves intact as much of the structure of centers and symmetries as possible.

6 / HOW THE FIFTEEN PROPERTIES APPEAR IN NATURE FROM THE UNFOLDING OF WHOLENESS

Let us now return to the fifteen properties which define living structure.[6] In nature, all living structure containing these properties comes into being without effort as a direct result of unfolding wholeness.

Think about the wholeness dynamically. Everything is changing constantly. Every process which occurs on earth continuously changes, transforms, modifies the wholeness which exists. So the wholeness is continuously evolving. At any given moment, in any given region of space, there is a wholeness W_t. At the next moment, this gives way to another wholeness W_{t+1}. The transformation of W_t to W_{t+1} is the way the world unfolds: $W_t \longrightarrow W_{t+1}$. Everything is covered by it.

What happens when the unfolding is *smooth*? The transformation is structure-preserving. At any moment t, there is a certain wholeness, W_t. At the next moment t+1, this leads to a new wholeness, W_{t+1}, which is *consistent* with the previous wholeness W_t; indeed, the next step, W_{t+1}, is one of the relatively few steps (of all possible steps forward) which is *very deeply* consistent with the wholeness W_t.

What this means, in a nutshell, is that during the transition to W_{t+1} the centers in W_t are not violated. They are preserved. Thus, in general, additional centers will be created that reinforce and strengthen the centers that already exist. In the cases where centers are taken out (death, pruning, simplification), they are removed, still, in such a way as to leave as many as possible of the larger centers intact. Under these circumstances, as layer upon layer of smooth unfolding takes place, what develops is a system of centers which is stronger, crustier, and more imbricated, and in which the centers (at first hundreds, then thousands, or tens of thousands) all reinforce and intensify one another.

The dense character of living structure, arrived at by a layered dynamic process in which wholeness is always being preserved as much as possible, *is exactly the character which has been described in Book 1, chapters 5–6.*

All this hinges on the fact that wholeness (as defined in Book 1, chapter 3) is entirely *made* of centers. Since it is made of centers, a transformation which preserves the structure of the wholeness must then preserve most of these centers.

From this it follows that the new centers which are created at each step will be related, *through repeated new appearances of the fifteen properties,* to the previously existing centers.[7] I have asserted, in Book 1, chapter 5, that the fifteen properties are the fifteen ways in which centers can enliven one another. Hence, if under a structure-preserving transformation, new centers are being added that enliven or deepen the existing centers, this means that the fifteen prop-

erties must slowly come into being, step by step, with each new transformation. Otherwise, the new centers will not enliven or deepen the older ones.

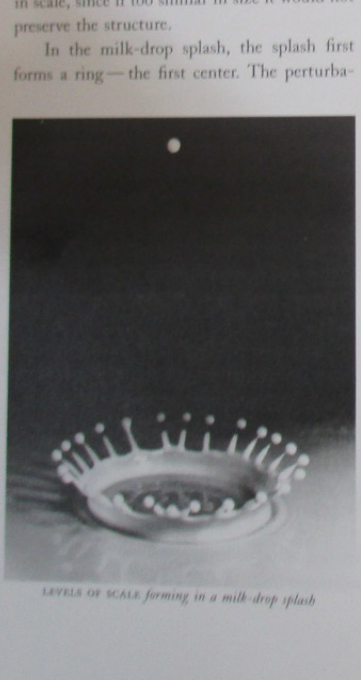
I am asserting that (to a first approximation) there are only fifteen ways in which this intensification of centers by other centers can take place. In other words, the presence of the fifteen properties in a naturally evolving structure, will increase as the evolution goes forward, as a direct result of the repeated use of structure-preserving transformations. Here are some examples of how it works.

1. LEVELS OF SCALE. For example, within a given center A or directly near it, we shall find smaller centers, B, one level of scale smaller. That happens because any perturbation or irregularity which develops near A causes the start of a latent center B. As this latent center gets stronger, the strengthening will then cause a nucleation near the first center. The nucleation *must* be at a jump in scale, since if too similar in size it would not preserve the structure.

In the milk-drop splash, the splash first forms a ring — the first center. The perturbations around the edge of the ring then aggregate in smaller drops — smaller, obviously, than the main ring, but not tiny. Their diameter is about one-quarter to one-tenth the size of the ring, and they give the milk-drop splash its LEVELS OF SCALE.

The process is quite general. If a large center is developing, and within it, somewhere, a small dot occurs (randomly), then to intensify this small center under structure-preserving transformations without disturbing the larger center, the small center must be kept *substantially* smaller than the first; yet if it is *too* small, it does nothing to enhance the larger one. If it has a scale at which it does not disturb and yet actively enhances the first center, the second one will be *just* one order of magnitude smaller than the big one. Repeated application of a process which enhances structure must create the property LEVELS OF SCALE.

Although the smaller drops that form around the crown of the splash break the infinite symmetry of the original continuous ring, they will now be arranged in a regular ring and be of roughly equal size. This is the same as saying the smaller drops must preserve the structure of the original



LEVELS OF SCALE *forming in a milk-drop splash*

STRONG CENTERS *forming in a flowering plant*

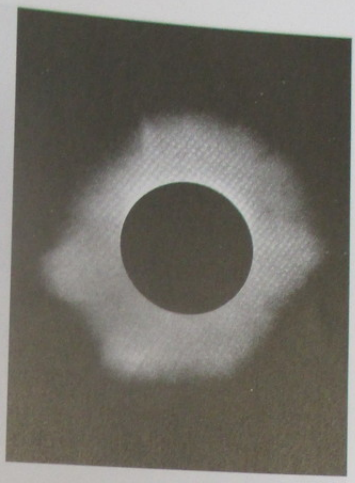
splash without drops, and must therefore still keep the "ring" structure. They can do this only if they preserve a symmetry around the center of the splash. Thus the perturbations that make the milk splash not only have LEVELS OF SCALE, but also make a strong center.[8]

2. STRONG CENTERS. Under structure-preserving transformations, STRONG CENTERS keep on increasing.

In the growth of a flower, a field effect takes place, caused by chemical gradients in the sap. As one center forms, the position of the flowerhead and the point of growth that will become a bud — stem, sepals, petals, and other parts of the flower — then develop and arrange themselves to support the flower that is forming. The medium of the transmission is the sap, containing ribosomes, enzymes, all together then creating a chemical field effect which stimulates growth of smaller centers placed in positions to enhance the original bud, and gradually giving rise to the fully formed flower as a center.

In general, in any system where one center forms, as structure-preserving transformations occur, other smaller centers will then emerge, will be intensified and themselves strengthened in just such a way that by virtue of their position and arrangement they intensify the first center. This causes the field effect around the first center which I have described (under my discussion of strong centers in Book 1, chapter 5). Gradually, it will occur around every center.

3. BOUNDARIES. At any moment in the evolution of a system, each center which exists has a latent boundary zone around it just by virtue of the nature of the center, separating it from adjacent centers and joining it to them. The boundary zone is the zone where the steepest gradient of differentiation falls off around the center, thus distinguishing it as a center. In one form or another it must occur, by definition, around any center. Under structure-preserving transformations, this latent boundary zone will intensify and encourage new centers to form within the boundary zone, as it strengthens the existing center, ultimately creating a big boundary which is strong in itself.



Formation of a BOUNDARY *in the sun's corona*

This is what happens in the sun's corona, in the piling of silt along the Rio Negro where it goes into the Amazon, or in the formation of the boundary around a human cell. The main center brings with it a boundary zone, and then (in many cases, like the cell) soon this boundary zone is filled with activity, forming additional and smaller centers that ultimately become structures in themselves.

The process is quite general. Gradually, under structure-preserving transformations, centers form boundaries, and the property BOUNDARIES will be found repeatedly throughout space.

4. ALTERNATING REPETITION. Inevitably, in every structure, events (and local structures) repeat. This is typical at all scales. Atoms, waves, leaves, grains of sand, cirrus clouds — all have repetition of some type of center, many times, spread through a portion of space.

ALTERNATING REPETITION: *waves and spaces between the waves in wind-blown sand in the sand dunes of the Sahara*

Consider the sand waves which typically occur in the wind-blown sand of big sand dunes. The crests come at more or less regular intervals, because the wind carries each sand grain a typical distance (determined by wind speed, and grain size). This causes a simple repetition. But as the wave crests grow, not only the crests, but also the depressions *between* the waves crests form. The structure-preserving transformations in the system then act to intensify both the hill-like shape of the crests, and the bowl-like depressions of the valleys. Both crests and valleys become more and more well-shaped, as a result of the structure-preserving transformations. The so-called empty space — actually space formed and shaped by the crests — then repeats *its* characteristic form, thus creating a second system of centers which repeat. These spaces become coherent, and alternate with the crests themselves, which, as centers, also repeat. The overall effect is ALTERNATING REPETITION.

The effect is general. In *any* repetition there will, obviously, be latent centers (not yet fully existing centers) in some of the spaces between adjacent centers in the repetition. Assume, then, that a structure-preserving transformation oc-

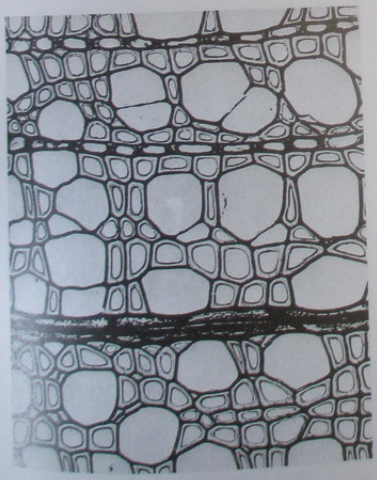
curs. The latent center between some pair of centers will develop and become a center in its own right. If the spaces between the repeating centers are themselves similar (as they will often be), this center-forming process will gradually occur in each one of the centers lying between the first system of centers — thus forming a second system of repeating centers tucked between the first system. After a number of transformations of this kind, there will be ALTERNATING REPETITION throughout the repetition.

5. POSITIVE SPACE. Consider a small zone of empty space somewhere in a system that is currently not inhabited with strong centers. By virtue of its geometry, at least some regions of this empty space will have a weak latent quality as centers. Like the empty space between two adjacent blobs, they will be center-like but undeveloped. Sooner or later, by moving material to make the shape of this "empty" space more coherent, structure-preserving transformations make these latent centers in the space more and more center-like. As they become centers they become more positive in shape. They will gather themselves together and differentiations will occur around the edge to intensify the shape and make it still more center-like.

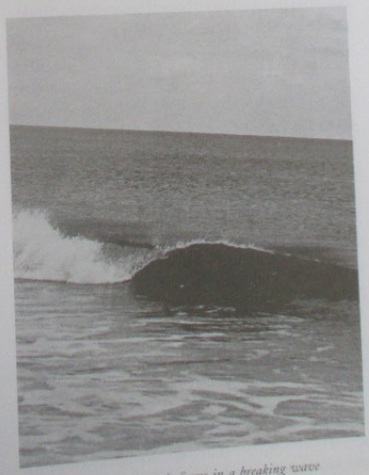
Look at the packing of kernels in a bit of wood tissue. While the tissue is growing, the wood cells press against one another, deforming their shapes, much as bubbles in a mass of bubbles keep their coherence under their own internal pressure, balanced against the pressure of nearby bubbles. Just so with the cells in the wood tissue, until each bit of space is made positive.

Under structure-preserving transformations, such a process will occur quite generally in any system. Gradually, each bit of space that has any latency to be center-like gets formed more and more strongly as a center. As the empty space is filled, pushed, pulled, connected, each bit of it becomes a center, and slowly becomes more positive. The property POSITIVE SPACE slowly makes its appearance throughout the space.

6. GOOD SHAPE. Consider an emerging shape within a developing whole. The shape often exists, at some early stage, as a weakly formed "possible" shape, not yet very sharply defined. As



POSITIVE SPACE *in the cell structure of wood tissue*



GOOD SHAPE *as it forms in a breaking wave*

GOOD SHAPE *of a single Ginkgo leaf*

The centers which form in the growing Ginkgo leaf. It is the formation and strengthening of these centers which then create a beautiful form, and GOOD SHAPE *in the leaf.*

structure-preserving transformations are applied, the latent centers which appear both within this shape and next to it, even if only dimly present, will be strengthened and made into a more definite center.

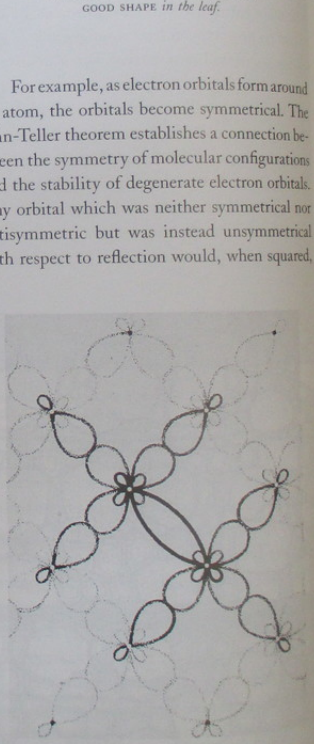
As a wave forms, at first it has a gentle shape, the rising swell of the wave-form. Then, as the wave develops, the shape becomes more and more pronounced, the non-homogeneity at the cusp becomes pronounced, the curl emerges as an independent center and finally, as the wave breaks, its shape becomes extreme and filled with centers.

As a ginkgo leaf forms the simple, relatively homogeneous curve around the compartments gives way to a curve in which each compartment becomes more pronounced, thus slowly creating a profound GOOD SHAPE.

Under structure-preserving transformations of a form, one by one, the vaguely existing centers within the shape are replaced by definite centers; as a result the shape strengthens. Gradually, throughout the space, just that character emerges that I previously defined as GOOD SHAPE: each shape is redefined so that it is made throughout of well-formed centers.

7. LOCAL SYMMETRIES. The centeredness of a given center is almost always strengthened by local symmetry — not always, but *almost* always.

For example, as electron orbitals form around an atom, the orbitals become symmetrical. The Jahn-Teller theorem establishes a connection between the symmetry of molecular configurations and the stability of degenerate electron orbitals. Any orbital which was neither symmetrical nor antisymmetric but was instead unsymmetrical with respect to reflection would, when squared,



LOCAL SYMMETRIES *in the electron orbits around a complex molecule*

yield a physically impossible probability distribution. In short, under evolution of the atom's quantum processes, the orbitals that form are locally symmetrical throughout.

More generally, during structure-preserving transformations, symmetrical and near-symmetrical evolution of centers maintains global structure, while "cleaning up" structural debris. Thus, at least some centers get reinforced and strengthened by LOCAL SYMMETRIES that intensify local centers. As structure is preserved, the density of LOCAL SYMMETRIES will typically increase: local symmetries, sometimes distorted to accommodate to other nearby structures, will appear more and more often throughout the space.

8. DEEP INTERLOCK AND AMBIGUITY. Along an edge between two zones, random perturbations will form disturbances which start as latent centers. As these randomly occurring latent centers get intensified, the centers go in one direction or another, into either one zone or the other zone along the edge. In many cases, there are additional functional constraints which make it desirable for these "edge" centers to belong to the larger centers on both sides of the line.

In the meandering river shown in the photograph, the centers formed along the two banks of the river have the river as a common edge. Gradually, as the history of the river develops, the centers shift. The centers which form on either side — both quiet places, and turbulent places in the stream — dig into and form an imbricated structure where the two parts of the land get spatially interlocked.

Very generally, along an edge which separates major centers, as minor centers along the edge get strengthened, they often swell in dimension, and penetrate more deeply into the zones of the two larger centers on either side of the edge. As a result of this process, centers are established which interpenetrate the larger centers, causing DEEP INTERLOCK. In those cases where the new centers may belong, functionally, to either one side or the other, the formation of the new centers will often also cause spatial AMBIGUITY.

9. CONTRAST. One result of a structure-preserving transformation is to give each center more distinctness, more differentiation from its surroundings. The differentiation can take many forms, but often requires opposition of contrasting polarities, either in density, or material, or charge, or color.

This effect can have surprising forcefulness. It is comparable to the process of leveling and

STRONG CENTERS *and* GOOD SHAPE *forming in the bending and winding of a river*

CONTRAST, *as it appears in the camouflage of a zebra's skin*

sharpening that occurs when we make a black and white xerox copy of a finely shaded photograph with gray tones. Differences get increased, so that the forms stand out more sharply.[9]

Increase of differentiation between peaks and valleys in an evolving mountain range is of this type; so are formations of the electric charge caused by differentiation of positive and negative; so are the differentiation of hard bone and soft tissue in a growing embryo. The process is so fundamental that it appears not only in obvious cases of polarity such as charge, but even in inexplicable cases of pure visual patterns like the zebra's coat. Technically, the patterning of the zebra's coat comes from growth diffusion mechanisms, under the control of genes. It has been claimed that this striping helps to camouflage the zebra in a shaded forest (where the zebra is protected from predators when seen against the striped pattern of light and dark falling through branches); also on the plains (where it is claimed that the stripes make the individual animal less distinguishable from the herd). But these evolutionary explanations are dubious and contradictory. What we can say for sure is that somehow the diffusion process autonomously causes a pattern of strongly contrasting pigmentation. Somehow the structure-preserving transformation starts with the weaker contrast of an earlier horse-like species, and intensifies it.

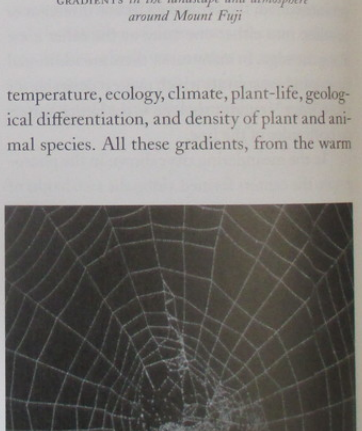
To accomplish CONTRAST, structure-preserving transformations increase the contrast of a pattern by intensifying both its internal differentiation and its differentiation from the surrounding environment.

10. GRADIENTS. When a center appears, the ongoing structure-preserving transformations do what they can to intensify that center. As a consequence, the space around the center will gradually be re-organized to include GRADIENTS of various kinds, which orient themselves toward that center, strengthening it by means of a field effect.

Above, for instance, we see a mountain where many simultaneous gradients exist from the lower slopes to the topmost peak: gradients of slope,

GRADIENTS *in the landscape and atmosphere around Mount Fuji*

temperature, ecology, climate, plant-life, geological differentiation, and density of plant and animal species. All these gradients, from the warm



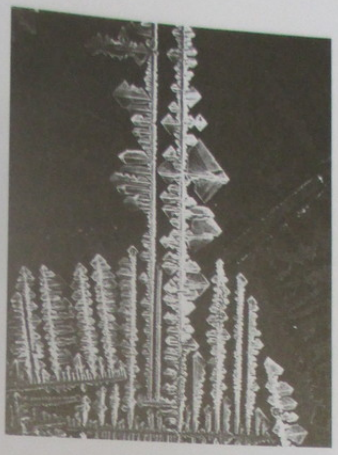
GRADIENTS *in a spider's web*

lower levels in a mountain range to the higher altitudes, where peak, rock, snow, and air have a different character, help to support the centeredness of the mountain peak, and make the mountain stronger. Some of these gradients come from a very long time ago, geologically (gradients of physical slope, rock type). Others come about as a result of climate gradients consequent on the altitude. Others then follow, as a result of biosolimes and vegetal adaptation.

A spider's web starts at the middle. The spider works her way outward from the middle in a spiral. In each successive ring of thread, the total enclosed area of the web-cells is about equal and the threads get closer together, as the spider has to walk across radials that are further and further apart, and needs something to hang onto. We may also think of this as an area-based effect, because the spider can only straddle a "cell" of roughly fixed area when walking, thus creating a pattern with rough centers related by an inverse square law for the radial dimension as a function of distance from the middle. As a result, centers forming a gradient make their appearance in the space.

More generally, whenever there is a center, for different but vaguely similar reasons, the geometry of space is likely to induce phenomena that fall off with something like an inverse-square law from the middle simply because of the geometry of space, thus creating GRADIENTS. In supporting and strengthening the center, these inverse-square related gradients will develop, thus forming gradient phenomena. As a result we may expect to find a variety of graded phenomena following formation of any center, where field strengths of the GRADIENTS point toward the centers, so reinforcing and strengthening the existence of the center. Slowly gradients will make their appearance throughout the space, around many of the centers.

11. ROUGHNESS. As a system comes to order, the structure-preserving pressure to form centers — especially larger centers — will often refine boundaries, edges, shapes, and connections in unusual and *apparently* inelegant ways that look like



ROUGHNESS *developing in crystal growth*

inaccuracies. However, these apparent inaccuracies are a direct result of careful and highly subtle adaptations, that come about inevitably as a result of the structure-preserving process.

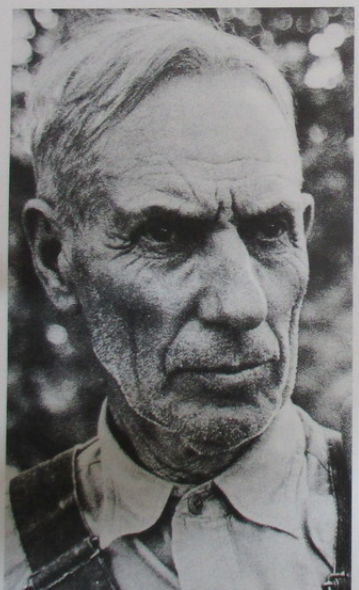
For example, in a system of growing crystals, the crystals take on different shapes and sizes. This is not only because of random fluctuations in the nutrient of the crystal growth but also because, as the large configuration emerges, in order to maintain the wholeness of the system in the large, more material is needed to fill in gaps in one spot while another spot is more crowded. To preserve the wholeness, ROUGHNESS and variations have to appear among the centers that the crystals form. To guarantee that the smaller centers really do work to form larger centers, the smaller ones are often made irregular, are syncopated in shape and arrangement, to fit the smaller centers smoothly into larger ones.

Slowly, in any structure-preserving process, ROUGHNESS always makes its appearance. Even among individual atoms, we see roughness. That is, we find imperfect similarity from one atom to the next within a crystal, even when the atoms are of the same type. Note, though, that ROUGHNESS

is only an *apparent* irregularity. Really, it is a necessary feature, the outward sign of deeper order as larger centers are perfected.

12. ECHOES. In any system where there are structure-preserving transformations, it is nearly inevitable that the same process will be repeated, locally, through zones of the system. In addition, some processes will be repeated, but with minor modifications according to context.

In the weatherbeaten face of this old man, the lines and angles make a similar pattern all over his face. Centers are organized with a similar morphology. This comes from the structure-preserving process. The folds in his skin are made by a similar process in different parts of his face; each one, locally, is the same process, applied to a different bit of flesh and skin. What results?



ECHOES *in the lines of an old man's face*

ECHOES appear from point to point throughout his face.

This is quite general. In every structure-preserving process, we shall find a great many cases where similarities of process create similar systems of centers — hence structural similarities, or ECHOES of similar angles and shapes — which bear a family resemblance to one another in the different centers where they appear.

13. THE VOID. Part of the process of structure-preserving requires cleaning out from time to time, just as an orchard must be pruned. When a situation appears where there are too many centers, too crowded together, in a confusion of structure, a structure-preserving process must be applied to the situation, since the conglomeration of centers becomes so confused that it begins to undermine the coherence of the centers. That means the process must act to discern the deep structure, the most important structure beneath the confusion. This important structure must then be preserved and the rest cut away.

As a result, structure-preserving transformations frequently act to create THE VOID. As structure is preserved, the transformations act to preserve distinctness. One of the ways this happens most frequently, is that dense highly differentiated structure gets set off against empty, clean smooth structure, and distinctness is maintained,

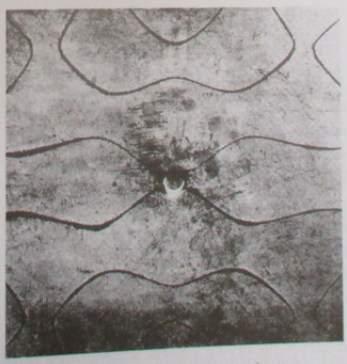
We may also express this by saying that crowded complex structure often ends up living at the edge of a much larger homogeneous void, and that the contrast between the intricate structure and the vast emptiness is needed to maintain the structure of the intricacy. In one illustration, we see the formation of voids in the Great Barrier Reef as a natural counterpart to the formation of living structure around the voids.

A similar process occurs at cosmological dimensions. There are huge structures in the cosmos, containing dense filaments of galaxies hundreds of light years in length, and these filaments are formed around vast volumes of relative emptiness. Current models of the formation of struc-

VOIDS *in the formation of the Great Barrier Reef*

ture in the early cosmos do not adequately explain the extent of these "empty" areas. However, the repeated application of structure-preserving transformations explains it as a result of the specialized symmetry operations that are needed to preserve structure in the unfolding whole.[10]

14. SIMPLICITY AND INNER CALM. As the cleaning out of irrelevant structure continues, centers will be further intensified by simplification. Slowly, a state appears in which nothing unnecessary remains present and in which all irrelevant or confusing centers that irritate the structure or reduce the value or importance of other centers are removed. This simplification occurs in nature constantly.



SIMPLICITY AND INNER CALM: *sand pattern left on a vibrating plate*

INNER CALM *in a Tuscan landscape*

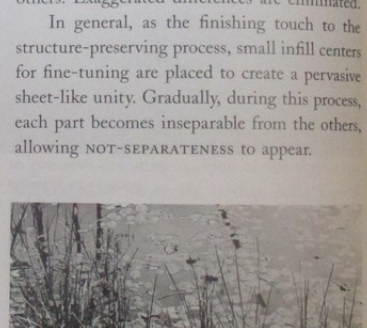
For instance, in the shape of the Chladni figures formed in sand on a vibrating plate (page 75), the sand moves toward the still spots in the standing wave. The standing wave, under the impetus of structure-preserving transformations, must take the simplest form. Even when people act as part of nature, such a process continues: in the field in Tuscany shown in the photograph, the cypresses simplify and substantiate the meadow. All is made simple and calm. Irrelevant and confusing structure is removed. Only the essential structure is allowed to remain, in a kind of simplification that is reminiscent of Occam's razor.

The SIMPLICITY of the state comes about naturally as the result of the structure-preserving process.

15. NOT-SEPARATENESS. The more the structure-preserving works, the more it brings out the underlying unity which exists in any system. This unity is preserved, and intensified, by the structure-preserving action. Thus throughout, as the structure develops through its uncompleted forms, the pressure to unify, and unify continues, by creating links, by wrapping each center into a web of other centers, tying everything together.

It is worth understanding just how the structure-preserving process accomplishes this. In the ecology of the lake edge (photograph, right), we see that the weeds, water, small creatures, bacteria, mud, and reeds in the shallow water create an unbroken tissue of organisms. Each part becomes wedded more firmly to the others. Exaggerated differences are eliminated.

In general, as the finishing touch to the structure-preserving process, small infill centers for fine-tuning are placed to create a pervasive sheet-like unity. Gradually, during this process, each part becomes inseparable from the others, allowing NOT-SEPARATENESS to appear.



NOT-SEPARATENESS *that has developed at the edge of a lake*

8 / FIFTEEN TRANSFORMATIONS

Let us now consider the fifteen properties, not merely as *results* of structure-preserving transformations, but *as the names of particular types of structure-preserving transformations themselves.*

Take, for example, LEVELS OF SCALE. We have seen in the previous section that levels of scale (viewed as a geometric property) will arise in a system naturally, as a result of structure-preserving transformations. We may, alternatively, think of LEVELS OF SCALE as a *transformation itself* which *introduces* levels of scale into a given structure. Thus, for any given structure, this transformation may be thought of as injecting into it, new centers which provide more beautifully articulated intermediate LEVELS OF SCALE. This transformation, whenever applied to a structure S_1, is likely to create a new structure S_2 that is a structure-preserving extension of S_1.

Similarly, LOCAL SYMMETRIES may be viewed as a transformation which injects local symmetry into emerging centers, strengthening weaker centers by injecting local symmetry into them. And BOUNDARIES may be thought of as a transformation applied to a structure S, which strengthens one or more centers in S by providing fat boundaries (themselves consisting of centers), to intensify and better define the coherence of the original centers. All three — LEVELS, SYMMETRIES, BOUNDARIES — are both property *and* transformation.

In general, all the geometric *properties* identified in Book 1 are also associated with dynamic *transformations* which will inject these geometric properties into the system of centers of any emerging, growing whole.

Let us consider in a little more detail, how the transformations work.

The LEVELS-OF-SCALE transformation introduces intermediate-sized centers to fill out the hierarchy of scales that exist in a given wholeness. In this case, some zone that has been loosely distinguished, is differentiated further into smaller parts. This can happen so that these new parts are similar in size to one another, but one level smaller than the center which is being differentiated. In another application of this transformation, a large center is made more coherent and distinct by the introduction of smaller parts, which then act together with the large center to form a recognizable and distinctive hierarchy.

The STRONG-CENTER transformation is the most fundamental transformation of all (and will be discussed further in chapter 7). Any weak center which exists is made more emphatic by this transformation. It may be more strongly differentiated, more strongly defined, more strongly integrated by virtue of its differences, or more sharply drawn and distinguished. Of course, all the transformations help, in some form, to achieve this fundamental goal. However, the transformation itself, in a primitive form, acts to give weight and definition and distinction and centeredness, to any weak center which has begun to crystallize in any given field.

The BOUNDARY transformation. Here the evolution of a given wholeness may take this form: First a zone of space is slightly different from its surroundings — a cloudy but distinctly differentiate zone with some "character" appears. How then, may this be further differentiated. One thing that can occur, is that the boundary transformation is applied. In this case, the zone (a ring zone, or spherical zone) becomes more distinct, and a thick boundary zone starts forming in a discernible way.

The ALTERNATING-REPETITION transformation generates a repeating pattern of similar entities, within a previously undifferentiated field. The way it works, though, it simultaneously generates

a second pattern of repeating centers, interlocking and alternating with the first. This transformation is the most basic way that a large system may be given a structure as a repeating field of many repeating smaller entities.

The POSITIVE-SPACE transformation makes strong positive space by creating new centers in the space between other centers, thus strengthening and shaping spaces between the other centers that are not yet centers themselves. This is one of the most powerful of the fifteen transformations.

The GOOD-SHAPE transformation takes an existing center or system of centers (often formed by earlier application of the ALTERNATING-REPETITION transformation). The transformation intensifies the products of the alternating repetition, by strengthening them, making them more distinctive — and this is done by applying the GOOD-SHAPE transformation and POSITIVE-SPACE transformation in the weakly existing centers in such a way that any loosely formed shape which exists in the space, is made more marked, stronger, by giving more life to the centers within the shape. The effect is to make a more beautiful, more living, shape.

The LOCAL-SYMMETRY transformation strengthens a center (or system of centers) by making the center (or each center in the system) have an internal axis of symmetry. The symmetries induced are only local, and do not extend beyond the limits of the center, and may sometimes even be used only to strengthen or "symmetrize" the kernel of the center. This is often the way in which an emerging center first receives its strength. Shortly after an entity is differentiated and made to stand out from its ground the symmetry transformation then sets it up as a strong center in its own right.

The DEEP-INTERLOCK transformation takes an existing structure, especially in its boundary zones, and weaves the distinct opposing parts at the boundary into a tighter, less separated, union by physically creating connections in which part of one enters into the other, and vice versa. This imbrication of the boundary cements the whole (the structure plus its context); the transformation helps to unify the growing whole. It would be unusual for this transformation to happen at the outset of a differentiating process.

The CONTRAST transformation is a kind of sharpening which occurs. In a system where two types of centers occur the transformation works to increase the distinction between the two kinds; it separates them more sharply from one another, thus creating a field of more strongly contrasting entities. The contrast may be achieved by color, darkness, polarity, or by other physical characterics. The polarity of the two, generates a more well-knit system as a whole in which the two kinds of centers can complement each other better.

The GRADIENT transformation creates transitions of size and character. In response to an uneven, or non-homogeneous field, certain aspects of size, shape, weight, darkness, spacing, are made to vary systematically — thus introducing coherence of a new kind into an almost random-like field of structure. The gradient transformation thus begins to create structure where none was visible before. In other cases, a simple polarity or position, or axis, engenders a gradient, and the inner parts and centers are then given features which vary systematically according to this gradient. In this case the GRADIENT transformation can have a very large, global, field effect within an extended zone. It has a surprising ability to order complex and inchoate structure, without greatly bending or changing circumstance.

The ROUGHNESS transformation. In the course of making positive space, strong centers, local symmetries, or alternating repetition, it is often necessary to introduce or pack in irregular variants of repeating centers, to make things work

out. The roughness transformation uses intentional irregularity to find the most regular fit possible for a given configuration, and one which permits things to work out successfully and simply in the large. It is of enormous importance. Wholeness would not be possible without it.

The ECHOES transformation applies procedures, angles, and shapes and shape-character of certain repeating centers to other centers in the field, thus generating a widespread family resemblance among different centers and so strongly unifying the whole.

The VOID transformation is at work getting rid of garbage. Areas which are relatively undifferentiated, and which do not need their differentiation, are cleaned out and made more homogeneous, and defined by a boundary zone which is attached, surrounded, by more differentiated structure. The transformation also preserves an imitation of the greater undifferentiated VOID.

The SIMPLICITY transformation, like the void transformation, also cleans, simplifies. However, it works by removing unwanted centers, differences, and other kinds of complexity, throughout the structure, where the void does it by creating a single homogeneous zone in one place. The simplicity transformation gets rid of unnecessary structure by reducing it.

The NOT-SEPARATENESS transformation may be thought of as a kind of knitting. In applying this transformation to an existing object or system of centers, modifications are made to the centers and their surroundings so that the center gains more of the subtle substance from its surroundings; and at the same time the surroundings gain more of the substance inherent in the center. The effect is that the two are brought closer together, forming a more indissoluble unity. All in all, the purpose of the transformation is to unify, to knit together, to create a texture in which the separateness of any given entity is reduced.

The way the NOT-SEPARATENESS transformation most typically works is somewhat similar to the effect of the color transformation called MUTUAL EMBEDDING (Book 4, chapter 7, page 192). When operating on two major areas, A and B, that are differentiated from one another, the transformation takes pieces of A and copies them inside B, and takes pieces of B and copies them within A. The result is that A and B become more associated, more allied, more united, and less distinct from one another. The not-separateness transformation may occur early or late in the differentiation of a structure. Essentially this transformation binds the entity which is being created and its surroundings more tightly. This may be accomplished by a variety of specific means including ECHOES, DEEP INTERLOCK, BOUNDARIES and so on. However, the overall unification of an entity and its surroundings, is a transformation in which the two distinct entities (a center and its context) are made more connected, more similar, more different, more interlocked, more reminiscent of each other, more complementary, more distinct, less distinct, and more united. The transformation stretches them apart and binds them together, making inside and outside less distinguishable.

Even under circumstances where the general principle of unfolding wholeness governs, what is it that makes these specific transformations occur? I do not know exactly how to answer this question. But loosely, one may compare it to the way that there are geometrical limits on the number of possible arrangements that can occur in space — as, for instance, in the limited number of different ways regular elements can be repeated to form crystals.

The inherent limitations of space have the effect that, for purely mathematical and geometrical reasons, there are only a certain small number of ways that a given wholeness can be extended, while preserving its essential structure. I have discussed this issue a number of times in Book 1, also

in chapter 1 of this book. Although I cannot claim to give a rigorous proof that the fifteen transformations are the only ways to extend and conceive a given wholeness, I believe that this is true, and that a more sophisticated mathematical treatment will one day be able to show why it is true.

The fifteen transformations form a coherent system. We have in them, a limited palette of transformations which may be made to act on a given system. These are the fifteen most basic ways in which structure-preserving transformations can be made to occur. Every differentiating process is accomplished, in a structure-preserving way, by successive application of these fifteen transformations. The range of possible sequences and combinations, and the range of results which can be achieved by this type of differentiation, is amazingly rich and varied.

We see now that the fifteen properties are not merely observable end-products of structure-preserving transformations. They provide the base transformations from which, in practice, *all* structure-preserving transformations are made. The world of nature — what we think of as nature, and what we think of as natural (whether it is brought into being by the innocent operations of nature, or made carefully by the thoughts and hands of men and women) is that world which is brought into being by repeated application of these fifteen transformations, applied again and again, to enlarge, and deepen, and evolve, and magnify the beauty of the world which exists.[11]

We shall return to the subject of these transformations throughout this book, and especially in chapter 7 and in chapter 16.

9 / A NEW VIEW OF THE NATURAL WORLD

As wholeness unfolds under the fifteen structure-preserving transformations, these fifteen associated geometric properties necessarily appear more and more often, and more densely, while latent centers are progressively being differentiated and intensified. This is why the living structure appears in nature.

Living structure appears in the wholeness as a direct result of repeated unfolding. If the evolution of the natural world follows a step-by-step

Mountain landscape after millions of transformations